SCHOOL SCIENCE AND MATHEMATICS

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EVERY WILD PLANT IS POTENTIALLY USEFUL

The Incas are said to have domesticated more wild plants than any other people.

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Our white potato plant was once a weed growing in the Andes Mountains. Its tubers were then about the size of a small pea. The ancient Incas worked with this weed until they had developed a dozen varieties which were useful at different elevations.

The Incas also gave us our Indian corn. In fact, it is said, the Incas domesticated more wild plants than any other people. Isn't that a challenge to us in this day of greater scientific knowledge? There are plenty of potentially useful wild plants with which to work. Anyone may find a valuable new variety if he looks for it.

All of our present crops were once wild plants. Any weed may be the ancestor of a new crop. It may be the ancestor of a plant which will produce useful human food. It may be the basis for a crop from which we can get material for our clothing, or for medicine, or for livestock feed; or it may be a potential rubber producing plant, such as the dandelion, or the milkweed.

It has been estimated that we know of over 250,000 species of plants growing in this world. Still, the Department of Agriculture recently published this statement: "Less than half of the world plant material that could grow here has had an opportunity to demonstrate its possibility."

The definition of a weed which has long been current has had a discouraging effect because the definition itself is negative. Textbooks define a weed as "a plant out of place."

When I worked with Luther Burbank in 1911, '12, and '13, I made a study of the results of his work and had many conversations with him, both in his gardens and orchards and in his home. He

showed me that his understanding of a weed was better expressed in this positive way: "A weed is a plant we have not yet learned how to use." Mr. Burbank saw the possibility of a crop plant in every "plant we have not yet learned how to use." Every wild plant had a potential usefulness in his mind.

This was the basis for the inspiration which resulted in his introducing more than 800 new varieties, many of which have become important crop plants.

Outstanding among the characteristics of wild plants is hardiness. We often call weeds "pests" because they are so hardy that we have difficulty in getting rid of them. This very hardiness is an asset when it is used in connection with developing a new crop plant.

Mr. Burbank frequently said to me: "Beaty, the most important characteristic needed in every crop plant is hardiness. A plant must have hardiness to grow where we want it to grow before we can get any use from it.

"I plant the seeds of wild crabapples to provide root stocks on which to graft seedlings. The wild roots have the hardiness needed. I get hardy plum trees in the same way. I use the seeds of wild plums to grow the root stocks."

Some of our useful crop plants have been brought here from other parts of the world, but it is not necessary to be a world explorer to find useful new kinds.

Useful New Varieties Come from Seedlings, Bud Sports, and Hybrids

Some seedlings found in the wild have been unusually beneficial.

In some cases, a bud sport on a tree has become a useful new variety.

In other cases, new varieties have resulted from natural hybridization or from hybridizing experiments conducted by man.

These three ways, the seedling, the bud sport, and the hybrid, are sources of new and useful varieties available to any one of us who will look for them.

An illustration of a chance seedling produced without the aid of man is the Golden Delicious apple. It was discovered in an orchard in West Virginia. The owner of the orchard said, "I didn't plant that apple tree. The Lord gave it to me." Stark Bros. Nursery Co. of Louisiana, Mo., purchased that tree—a seedling—and made it available as an important orchard variety.

An apple called Starking Delicious was found by an orchardist as a bud sport on a Delicious apple tree. All of the fruits on one branch turned a bright red several weeks before the other apples on the same tree were ripe. This bud sport has been propagated as a new variety.

The third method, that of hybridization, was probably used more by Luther Burbank than by any other one man before or since. While he found many useful seedlings among wild plants, more of his varieties were the result of purposeful hybridization. He carried the pollen from a wild plant to a similar plant already used as a crop plant, and he carried pollen from the crop plant to the pistils of the wild plant. Thus, he made crosses both ways. From these crosses, he planted thousands and thousands of seeds. This, anyone else can do.

A Plant Breeder Must Have a Specific Purpose in Mind

It should be emphasized, however, that before such a cross is made, the plant breeder must have in his mind some specific characteristic for which he is searching.

When Luther Burbank began work with wild plants which eventually resulted in the Shasta daisy, he had very definitely in mind that he wanted to find a large pure white flower growing on a plant that was graceful and not too leafy.

He started with the wild ox-eye daisy which grew luxuriantly in the pastures of New England. It was a weed there. It was a pest to the farmers. It took up space where farmers wanted grass in pastures. To the farmers, it was indeed "a plant out of place." But to Luther Burbank it was "a plant we have not yet learned how to use."

He took seeds of this wild new England daisy to California with him when he moved there in 1875. He planted these seeds in California and discovered quite a variety of blossoms, apparently as a result of the change in climate.

The scientific name of this weed is "Chrysanthemum leucanthemum." Later he was able to get a wild flower from England with the scientific name "Chrysanthemum maximum."

He crossed these two. Some of the hybrids had blossoms which were a marked improvement over either parent. They were larger, but all of them had a yellowish tinge, and Mr. Burbank wanted a pure white flower.

A little later, he was able to get seeds of a wild daisy from Germany with the scientific name "Chrysanthemum lacustre." The plants which grew from these seeds were crossed with hybrids which had been produced by the first crossing. Still, the type of flower he was looking for was not forthcoming. He did find improvements, but none of the blossoms were white enough.

Finally, he discovered a fourth daisy growing in Japan with the scientific name "Chrysanthemum nipponicum." The important thing about the blossom was that its petals were extremely white. The blossoms, however, were small. He used pollen from the plants grow-

ing from these seeds to make crosses on the hybrids of the three other species. He had hybrid plants which were producing large blossoms, but most of them had a slight tinge of yellow. They were not sufficiently white to satisfy his desires.

However, after growing thousands of hybrids, making many selections, and destroying thousands of plants which did not satisfy him, he one day found a plant which had blossoms whiter than all the rest. It was growing in a hedge of these new daisy hybrids on his Sebastopol place. He told me of the discovery in these words:

"I was walking along the hedge one day when I saw one blossom that was whiter than all the rest. It was so different to my eyes from all the others that it might just as well have been black. It would not have been any more conspicuous. It was the whiteness for which I had been searching for years.

"I wondered, however, whether other people would see the difference as I saw it, so I led my workmen, one at a time, right past the white blossom. Each workman said that he saw no difference; all of the blossoms were white to his eyes.

"As visitors came to see me, I led them past this white blossom, but none of them could pick it out. One day, a woman artist from San Francisco saw that one blossom stand out from that whole hedge of blossoms—several thousand—just as plainly as I saw it. Apparently, our senses of color had grown to be more keen than others because we used those senses more often."

When Mr. Burbank had visited Mt. Shasta in northern California some years before, its mantle of white snow had caused him to decide that, when he found the white daisy he was looking for, he would name it for this snow-covered mountain. Consequently, he designated this new race of plants "Shasta daisy."

Bulletin No. 691 of the College of Agriculture of the California Experiment Station by W. L. Howard says the following regarding the Shasta daisy:

"Creation of a new race of daisies by breeding and selection was one of Burbank's outstanding accomplishments. Though the details of the ancestry are incapable—at this late day—of scientific proof, the fact that he did produce the Shasta daisy by breeding, essentially as claimed, is attested by professors E. J. Wickson of the University of California and Hugo de Vries of the University of Amsterdam.

"For all practical purposes, the Shasta became a new race of daisies. It was an immediate success in this and other countries and is as popular now as it was forty years ago."

This work was begun about 1884 and was completed in 1901. There are many varieties of Shasta daisies sold by seedsmen every-

where. Certainly, this is an outstanding example of what can be accomplished by hybridizing wild species.

Wild Varieties of Bush Fruits Were Useful

Crosses were made between the wild California dewberry and the Cuthbert raspberry. A resulting hybrid was sold to John Lewis Childs who introduced it as the "Phenomenal Berry." "It bears a marked resemblance to the loganberry and is considered by growers as superior to that variety," says the *California Bulletin*. "It is still found in the markets of California."

A clear white blackberry named "Iceberg" was introduced in 1894 which resulted from crossing a wild blackberry which was not black but still not white. Furthermore, the fruits of this wild blackberry were so small and the seeds were so large that it was useless as food.

He crossed this wild plant with the Lawton blackberry which was one of the best commercial varieties at the time, and later found the hybrid bearing clear white berries. While the Iceberg has never become a commercial variety, it does illustrate what can be done by making use of wild plants.

Wild Walnut Pollen Gave Surprising Results

In 1893, Luther Burbank introduced a hybrid walnut tree which was named "Paradox." It was the result of a cross between the English or cultivated walnut, *Juglans regia*, and the northern California wild black walnut, *J. californica*.

Another walnut introduced at the same time was a hybrid of the California wild black walnut and the Eastern black walnut known as *J. nigra*.

These hybrids were both fast-growing varieties. They produced a fine quality of black walnut lumber in much less time than either wild parent had ever done. A Paradox black walnut tree growing on Luther Burbank's grounds at Santa Rosa at sixteen years of age was sixty feet high and the trunk was two feet in diameter at about four feet from the ground. English walnuts growing on the opposite side of the street averaged only eight or nine inches in diameter at thirty-two years of age. In other words, the Paradox was a rapidly growing timber tree.

The nuts have great value for growing root stocks for English walnut trees. They were in great demand in California where there are many large nut orchards. In one year, Mr. Burbank sold more than $1,000 worth of nuts from one royal walnut tree for this purpose. The root stocks grown from the nuts of this variety enable a tree to produce several times as many nuts as when growing on its

own roots. The trees grown on these root stocks are also less subject to blight.

The Plum Shipping Industry Started with Wild Seedlings

The beginning of the tremendous plum shipping industry on the Pacific Coast was in 1885 when Luther Burbank imported a number of wild plum seedlings from Japan. In 1885, the plums growing in America were largely wild varieties and were small, as compared to the fruits which grew on two of these imported seedlings.

One of these seedlings bore fruit the year after it was grafted on to a plum tree on Mr. Burbank's grounds. The fruit was very large, heart shaped, red with white bloom, and very good in flavor. When he showed this plum to Professor H. E. Van Deman of the U. S. Department of Agriculture, Mr. Van Deman urged Mr. Burbank to introduce it, and Mr. Van Deman named it the "Burbank" plum.

Its large size, its flavor, and its attractive color made it popular at once, and in just a few years, California plum growers were shipping 125 carloads of the Burbank plum to eastern markets each year. This plum has proved to be of tremendous value in more places in the world than any other variety. The tree is able to adapt itself to more different kinds of weather and soil conditions than others. It lives through cold winters. It also survives the hotter conditions experienced in South Africa.

One of the other seedlings first bore fruit in 1887. It was a plum with red skin and dark purplish red flesh. It averages two inches in diameter. Mr. Burbank introduced it as the "Satsuma." It became popular in Southern California and many of the eastern Gulf States as well as in the southern hemisphere. It could not be grown in colder places, however.

There is opportunity for any one who will study those plants which we have not yet learned how to use and look for seedlings, bud sports, or hybrids which are better than what we have.

The possibilities are indicated by the report made by W. L. Howard of the University of California in which he says: "Briefly, Burbank introduced over 200 varieties of fruits alone. Plums were his most valuable contribution. Twenty of his varieties—18% of the total introduced—are still widely planted throughout the United States and other countries. Ten of the number are standard shipping varieties wherever Oriental plums are grown for marketing, as in California, South Africa, Argentina, and Australia.

"In California alone, they form the basis of a major industry. At present (1945), there is in this state a total of about 24,000 acres of Burbank varieties—upwards of two million trees. Thousands of car-

loads of fruit are shipped annually and the money returns run into the millions—not a bad showing for the industry of one man."

COORDINATING SCIENCE AND MATHEMATICS

The Central Association of Science and Mathematics Teachers is unique in that it serves both science and mathematics. Through nearly 50 years of existence the integration and cooperation of science and its co-partner, mathematics, have been actually and successfully practiced.

In the 1949 convention to be held at the Edgewater Beach Hotel, November 28–29, this same phase of cooperation will be in evidence. Two speakers on the General Program will demonstrate the integration of science and mathematics, and the School Groups on Saturday morning will have programs developed around both science and mathematics of interest at the elementary, junior high school, senior high school, and junior college levels.

Not only on Saturday morning but also at the Friday Sectional meetings, programs will contribute to the various levels of science and mathematics education, namely elementary, secondary, and college teaching.

Since the next issue of the JOURNAL will be October it seems advisable to recommend now that early room reservations with the Edgewater Beach Hotel will be of benefit to you and appreciated by the Hotel. Address such reservations to Mr. E. J. Ahern, Reservation Manager.

Mr. Edgar S. Leach, Evanston Township High School, is Chairman of the Banquet Committee for 1949. He will be happy to receive advance reservations from you for the banquet.

We wish you a pleasant summer and cordially invite you to be with us in November.

CHARLOTTE L. GRANT, *President*

DESIGN NEW REFRACTOMETER

Production of a new refractometer for testing and controlling the quality of chemicals, foods, and oils was announced by Bausch & Lomb Optical Company.

The portable, electrically illuminated instrument affords accurate refractive index readings in less time than was possible with previous instruments, according to Warren H. Slocum, of the optical firm's analytical instrument division.

Its detachable prism system may be removed by the user and replaced quickly with a duplicate set to avoid layoffs, should repairs become necessary. Previous models required factory servicing, involving several weeks' delay when it became necessary to recondition prisms.

Other features include a built-in, corrosion-free glass scale, a dust-proof housing and illumination system, and stationary eyepieces, Slocum added.

The refractometer is one of the most widely used optical instruments. The new instrument is expected to permit further advances in research in chemistry, medicine, and physics and aid industry in improving product quality.

MANY WILDLIFE REFUGES

A total of 282 wildlife refuges have now been acquired by the U. S. Fish and Wildlife Service. They total 18,000,000 acres of land. Chief objective is to preserve wildlife and birds which are in danger of extinction.

GLORIFYING THE HIGH SCHOOL PROJECT

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In a few weeks several hundred thousand young men and women will be leaving the high schools of this country to the collective sigh of relief of thousands of high school teachers. The commencement speaker will tell these graduates, in too many words, that they are about to set sail from the placid waters of the harbor of their school days into the turbulent seas of life. What he won't tell them is that no one thought of supplying them with a rudder. The great majority of them will be completely devoid of a sense of spiritual values, of habits of study, of concentration or of mental discipline. In short they will be as nearly unequipped for success in life, in marriage or in business as their less fortunate fellows who did not have the advantages of a high school education. Most of them will be struggling blindly and a little confused to build a future on something which they vaguely feel should be theirs, but somehow has escaped them in the four years of school.

It is possible today for a high school student to spend four years in a system, which by an ingenious arrangement of courses, permits him to exercise the very minimum of his talents and guarantees him no return on the investment. Regardless of what course he follows, he will certainly engage in a multitude of activities, some of them not even distantly related to education. Most of these activities have been thought up by his teachers over a period of many years, until they have become almost an integral part of the educational system. Today, these same teachers will tell you that these activities are necessary because the students cannot do without them. In most cases the student has been convinced that he not only needs them but loves them.

Among these activities one which is outstanding because of its utter futility as a means of instruction, is the so-called "project activity." By exercising it to its fullest extent a none too promising high school student can, by diligent application of a pair of willing hands and sharp tools, emerge at the end of four years, a none too promising graduate, to become a less than promising college freshman. To him, this limerick could be aptly dedicated.

> There was a young student named O'Hare
> Whose IQ was just passing fair.
> He cut and he pasted,
> 'Til four years were wasted,
> And departed none the worse for the wear.

I refer to the "project" or "scrap-book" student who has been

conditioned to do things rather than learn things—who is trained to visualize through pictures what he cannot grasp through mental effort. In using the word "project," I do not wish to condemn all such types of activity which may, in their proper place, prove of some value to the student. Nor do I wish to confine the criticism to such projects alone but to all such forms of activity which are rapidly becoming a substitute for any form of serious mental effort. It is the present day trend to confuse external activity with the learning process which is at fault. It is this trend which is to be deplored and the influence which such thinking has had on both the high school curriculum and the pattern followed by some of our science textbooks.

From the first let me define the meaning of this particular form of activity and point out some of the classifications. A project can be lightly defined as a carefully outlined, over-emphasized activity which, if the student never heard about it, would be just as well. It consists, in its primitive form, of buying an expensive scrap book and then filling it with unrelated and often ill-suited cut-outs from pictorial magazines. This is the lowest form or, "Oh Mother, see what I have done" type of project. Fortunately, either the lack of initiative on the part of the teacher or the limited imagination of the student has confined this phase of the project activity to the lower grades and the freshman year of high school. Then there is the in-between or "Well, boys and girls, what shall we do today" type of project, which goes on to the more complicated and presumably more skillful task of building things. This is a third dimensional field and requires both manual dexterity and a set of steady nerves. Projects of this kind are exhibited in school room cabinets on open-house night and take the form of block houses (see *Robinson Crusoe*), ship models (see *Treasure Island*) and plaster of Paris models of various undefined and unrecognizable objects. The usual remark heard at these exhibits, interspersed between the ahs and ohs of fond parents is, "What's it supposed to be?"

Finally we have the upper level of activity which is dignified with the name of "science project." These projects result from the fertile imagination of the science teacher; for science is a fruitful field for projects of every description. As a rule they are not received with too much enthusiasm because by this time Junior begins to suspect why he is in school and is frankly bored by the whole business. Projects of this type combine most of the talents required for the first and second variety. The completed project eventually finds its way into Junior Achievement groups, Science Fairs and Science Club exhibits, where suitable awards are given.

Let us see what the scholastic life of Junior would be like if a few of his teachers became "project-minded" at the same time. First the

English class. Here Macbeth is the subject under discussion. of course there must be a scrap book to arouse and sustain an interest in such a person as Shakespeare. Seemingly he cannot be appreciated for himself or for his works alone. Therefore, a sequence of pictures must be pasted in a scrap book. These usually represent the "sleep-walking scene" since the proponderance of negligee advertisements makes this a relatively easy assignment. Many of the students' efforts in this regard are remarkable only in so far as it takes a thorough knowledge of Shakespeare to see any connection between the scrap book and what it purposes to illustrate in the play. In history class, Junior diligently and dutifully drew a map of Europe and represented each nation with different colored crayon. Now this looked very pretty and no doubt took time and a good deal of effort, but unfortunately no one asked Junior where Italy was in reference to France nor the size of the German empire before the downfall of Hitler. Then to sociology for which Junior was well prepared. Had he not spent nearly the entire evening (or at least the greater part of his favorite mystery program) preparing especially for this assignment? For proof of it he had a beautifully drawn reproduction (copied from *Life* magazine) of a typical sewage disposal plant in any typical large city. He didn't know what sewage was nor why there should be a disposal plant, nor did he have any idea just how this affected the tax-payer in this typical large city. But he did have a nice picture of it, on which he understood most of the week's grade would depend.

It was true the Math course was going to be a little rough—but then how can a fellow be expected to work ten problems in trigonometry? The teacher was getting a little too unreasonable about constantly demanding that a fellow wear his brains out with sines and cosines and solving identities. It was a very shocking discovery to Junior when he finally found out what Trig was like. But then there was always the consolation of the chemistry course which followed the Math. He was really prepared for this week in chemistry. This was the project to end all projects, for Junior had built an atom bomb. Oh, not really an atom bomb you know. Just a huge wall-sized chart copied from a picture he had seen while browsing through *Popular Mechanics* in the library. In this, among other things, he had shown what a cross section of the atom bomb was like and the mechanism that made it explode. Of course he had forgotten that this was all mere conjecture and that it wasn't necessarily the way the bomb really worked, but it made an impressive display and was sure to raise Junior's chemistry mark at least ten points for the term. Who knows, if he was lucky it might even win a prize in a science exhibit.

Perhaps I have over-drawn the picture of Junior and his projects. If so, it has been intentional. But suppose that each teacher, during the course of the same school day became project minded. Would not this represent a typical picture of Junior's home assignments for that day or that particular week? I know that each of the above mentioned projects has been given by teachers for I have seen the results displayed prominently and proudly in class rooms and assembly halls.

Now just what, if anything, do these projects accomplish? What faculties of the student are called into play? And here the word "play" is quite meaningful. An inborn sense of proportion and neatness, a sharp scissors and a can of glue would suffice for any one of the above projects. Does the student remember anything about Denmark or any other country because at one time or another during his high school career he has colored it green? Can a student write a better sentence because he has cut out a picture of a movie star to illustrate the "sleep walking scene" in Macbeth? And where is the connection between understanding the electron concept of matter and a paste-up of the atom bomb?

Many teachers will defend the project idea because it "stimulates and creates an interest" in the subject. If this is true then a number of teachers have been sorely neglecting a very important phase of the education of their students. I doubt very much if there is any stimulation in projects of the above type. Rather it is confusing knowledge with activity—knowing with doing. Much is being done on the surface but little if any development is taking place in the minds of students exposed to this type of stimulating exercise.

Above all this sort of scrap book pasting is certainly out of place in the science class, where the laboratory should be stimulating enough to give the student an additional interest in the subject matter. The satisfaction from "doing" can be acquired from a combination of mental and physical activity and the science laboratory should certainly do just this. I am very much afraid that by encouraging project activities, we are digging at the periphery while the solid core of knowledge remains untouched. If it is true that an intensive course in science is for only the few outstanding students, then we should at least be preparing these few for the leadership of many who must build projects and paste-up posters in order to sustain an interest in the science course. A stiffening of the requirements of the science course, an understanding that the mastery of any field is difficult and requires hard work, as well as an appreciation of the fact that hard work is rewarding in itself—these can be the stimulants which will just as readily create a lasting interest in science and provide a much needed mental discipline as well. A sus-

taining interest *can* be acquired from an appreciation of the laws of science. It is not necessary for the teacher to outline a series of projects in order to maintain the student's interest *if* the science course is well prepared and well taught.

Science is the pursuit of truth and we cannot seek it through the mind of the student by distracting him with useless activity. Science clubs as well as science projects can and should *follow* as a natural outgrowth of interest in science and not be used to *stimulate* an interest in science. The science club should contribute to the essential matter of the course and should point toward the same objectives as the science course. If the chief aim of the course is entertainment or the development of manual skills, then certainly scrap books should be used in order to help attain this objective. If the main objectives of the course are to learn scientific truths, develop scientific procedures and arouse an appreciation for science, then projects and scrap books have no place in the field, for none of these objectives are attained by building plaster of Paris models. They serve but to confuse the real purpose of science with a make-believe façade of external activity.

Science clubs should be devoted to reading, thoughtful investigation and research, and solving problems that arise from such reading and research. In this the teacher, if he be a true scientist himself, is the guide and inspiration and the laboratory is the natural outlet for such investigations. In this way and only in this way, do science clubs fulfill their true purpose. The principal gauge to be applied to any project proposed by the teacher should be one of stimulation of thought. Does it require the student to do independent thinking and further research as a result of this thinking? The type of investigation carried out by the winners of the science talent search should be a good criterion for such science club projects.

Admittedly all this requires the efforts of the better students, but the science club should furnish an outlet for this type of student, and not for the average run-of-the-mill student who engages in such projects for the purpose of raising his marks or because he is a joiner and must belong to every and all organization and club the school has to offer. Students of a type do crave solid food and they can digest it. Why then, ladle out the predigested variety and stunt the natural growth of the child with paste-ups and activities which challenge neither his initiative nor his brain powers? He is asking for leadership, for discipline and for truth—it is in our power as teachers of science to give it to him.

We can create giants but we insist upon turning out mental pigmies under the preconceived idea that students are not able to grasp even the most fundamental concept of a scientific truth. Is it logical

therefore, to substitute something which is not true for the truth which we believe they cannot digest? Today we face the apparent paradox of a civilization which is showing an increasing interest in all the fields of science and a student population which is progressively dropping off in science enrollment. If the fault does not lie with science teachers and those who administer the policies of the high school, then wherein does the fault lie? Possibly we have watered down the science course until the student no longer has any desire for something which to him has lost its usefulness. In seeking scientific truth and in our attempts to impart it to the student, however discouraging this may become, it is the duty of the science teacher to seek it doggedly and perseveringly, without taking time out from the essential objectives in order to stray into the remote byways of projects and pageants.

It is time that science teachers come back to the fold and re-examine their objectives, re-specify their aims and re-define the meaning of education in science. I often wonder if some teachers are feeding their students on project activities because these externals are demanded by the student or because the teachers want them or need them since they give a false sense of progress—a visual accomplishment which they can hold up for all to see. We should among other things, re-examine our sense of values. Does the science course help to prepare for leadership—a leadership with a deep spiritual realization that science is to serve humanity and the individual through unselfishness, sacrifice and devotion? Certainly the opportunities are many of bringing a student to a sense of these spiritual values through science education. The youth of today are crying for leadership and we who can give it to them through the medium of a science course are reaching them plaster of Paris models instead of bread.

I believe that our high school science courses can be re-established in their rightful place in the curriculum if corrective measures are taken to improve both the quality of teaching and the subject matter of the courses. This can be done by re-examining and re-evaluating the objectives of the science course. The first objective should be to impart an understanding and appreciation of the simple laws and principles of science and should be arrived at through diligent pursuit of the meaning and function of these laws in our modern civilization. But first it will be necessary for the science teacher to convince himself that a student is capable of attaining this end. Evidently we must remove the false idea that a subject must be made easy in order to be attractive to the students. Certainly a great deal of basic training is necessary, both in study habits and in mental discipline, in order to raise the level of student attainment so that he can master these fundamental subjects. The opposite trend, that of lowering

the standards of the course, or sugar-coating it with non-essentials is quite evident today. The result is that we are shaping our science courses to fit the lowest degree of attainment rather than insisting that the student be raised to the level of requirement of the science course. The latter is the line of least resistance but unfortunately the trend is progressive and it is hard to understand where the downward course will stop.

Lastly, the science laboratory, if it is going to be effective at all must be the focal point for resolving some of the difficulties encountered in the lecture room. Again the objectives of the course must be clearly stated and rigidly adhered to. For otherwise the laboratory becomes just another place to continue a series of disorganized thought processes begun with the textbook and the lecture period.

It is unfortunate that the tendency to emasculate the subject matter for the easy assimulation of the mediocre student has become so prominent in the laboratory practice. What an excellent opportunity the laboratory offers for clear thinking and scientific reasoning; for instilling the fundamentals of the scientific method and for forming sound habits of observation and deduction. What a waste of effort and of opportunity if it were to degenerate into a workshop for projects and pageants.

CLEVELAND NORCROSS

Cleveland Norcross, General Manager of the American Institute of Physics, 37, died March 21 at the Neurological Institute after an emergency operation for a brain tumor.

Prior to joining the Institute staff, July 1, 1947, Mr. Norcross was executive secretary of the Office of Scientific Research and Development, and during the war he administered the expenditure of a half billion dollars in research contracts. For his services to the O.S.R.D. he was awarded the Certificate of Merit at the direction of the President of the United States.

DEGREES BY THE THOUSANDS

Nearly a third of a million degrees were conferred by colleges and universities in the United States during the year ending June 30, 1948. The Office of Education, Federal Security Agency, made this announcement today in reporting for the first time the actual number of earned degrees of each level (Bachelor's, Master's, and Doctor's) conferred in each field of study by each of 1,214 higher educational institutions across the nation.

INSTITUTIONS GRANTING LARGEST NUMBER OF DEGREES

Bachelor's		*Master's*		*Doctor's*	
Univ. of California	7,103	Columbia University	4,819	Harvard University	310
Univ. of Minnesota	5,435	New York University	2,200	Columbia Univ.	277
New York University	5,295	Univ. of Michigan	1,912	Univ. of Wisconsin	197
Univ. of Illinois	4,395	Univ. of Chicago	1,257	Univ. of Chicago	181
Univ. of Michigan	3,768	Univ. of Illinois	1,033	Univ. of California	159

AN ATTEMPT TO MEASURE CRITICAL JUDGMENT

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The difficulties associated with the evaluation of the objectives for the teaching of plane geometry are not peculiar to plane geometry, for all teaching areas have accepted, but intangible objectives. The millennium will have been reached when all accepted objectives become tangible, but progress is retarded by teachers who tend only to test for the easy-to-measure objectives. The commercial tests encourage such limited evaluation, for they usually provide measures of fact-retention and manipulative skills. Such measures are important, but shall measurement of pupil achievement be so limited? Geometry teachers indicate verbal acceptance of "critical thinking" as of primary importance, but does one find the classroom experiences directed toward this end? Even a most superficial survey will indicate a prevalent hiatus between the verbal acceptance of "critical thinking" and evidence of measuring this objective, or classroom experiences designed to teach for this objective. Too many teachers accept automatic transfer from the deductive thinking in plane geometry to its use in more life-like, non-geometric situations. Available research[1] and commission recommendations make such teaching indefensible. A survey of tests and texts reveals that re-direction is necessary if teachers are to be provided with resources for the measurement of, and teaching for, the objective of critical thinking.

The use of the term critical judgment seems more convenient for measurement and teaching, for a person who thinks critically is constantly making critical judgments. Perhaps critical judgment is more limited than critical thinking, and if so, only a partial measurement of critical thinking will be secured by a "critical judgment test." Critical thinking is also accepted as an objective by teachers of English, speech, social studies, and other areas concerned with the development of a discriminating listener and reader. The contribution by the geometry teacher will be dependent upon the pupil experiences provided, and the definition of critical thinking accepted. This contribution must be unique in emphasis, if not in kind.

A recent survey of available commercial tests reveals, there are but two tests that a high school geometry teacher may choose to secure some measure of the students' ability to think critically in non-geometric situations. These two are: "The Cooperative Test of Social Studies Abilities"[2] and the "Watson-Glaser Tests of Critical

[1] Orata, P. T., "Transfer of Training and Educational Pseudo-Science," *The Mathematics Teacher*, Vol. 28, May (1935), pp. 268–282.

[2] J. W. Wrightstone, *Cooperative Test of Social Studies Abilities*, New York: Cooperative Test Service, 1936.

Thinking."[3] Why the dearth of tests to measure this commonly accepted objective? Perhaps the difficulty involved in attempting to measure such an intangible objective discourages the teacher, or have the teachers not indicated sufficient interest in purchasing such tests? At least one test publisher will consider publication of tests of hard-to-measure objectives only when there is sufficient demand. Because such a status now exists, Mr. Frank C. Hackman, teacher at Lexington, Illinois, and the author were concerned with providing a test to measure some teachable aspect of critical thinking. Two questions seemed evident—"Why is it important to teach for critical thinking?", and "What does a person do who thinks critically?"

Recent commission reports give data on the importance of this objective. The Harvard report[4] states:

> Though it is of course possible to learn to reason deductively without the aid of instruction in demonstrative geometry, no better example of an abstract logical system within the reach of a secondary school pupil has yet been discovered.—The projection of the structure of geometry into areas of more immediate and often more practical interest to the student should be taught explicitly. It is only in this way that there can be accomplished the "transfer" of mathematical values to other spheres of human interest, which is a primary concern of general education.

This is especially significant, for the members of the Harvard committee accepted this statement unanimously. Three of the twelve members of the Harvard committee were directly associated with the teaching of, or research in science, and no one on the committee was concerned with the teaching of, or research in mathematics. The fifteenth yearbook of the National Council of Teachers of Mathematics[5] recommends that teachers should strive to have all pupils develop "a clear grasp of what is meant by deductive science; and the ability to apply the method of postulational thinking in life situations not specifically mathematical." The last part of this statement, "not specifically mathematical," is of special importance, because teachers are urged not to limit themselves to mathematical situations in the teaching of critical thinking. This commission report assumes that in order to have postulational thinking affect the lives of people, life situations must be brought into the classroom. The Progressive Education Commission publication entitled, "Mathematics in General Education"[6] gives the following statement, "Fundamentally, the end sought is for the student to acquire both a thorough understanding of certain aspects of logical proof and such related attitudes and abilities as will encourage him to apply this

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[3] *Watson-Glaser Tests of Critical Thinking*, Yonkers-on-Hudson: World Book Company, 1943.

[4] *General Education in a Free Society*, Harvard University Press, Cambridge, Mass., 1945, pp. 163–164.

[5] *The Place of Mathematics in Secondary Education*, New York: Bureau of Publications, Teachers College, Columbia University, 1940, p. 93.

[6] *Mathematics in General Education*, New York: D. Appleton-Century Co., Inc., 1940, p. 188.

understanding in a variety of life situations." Again note the last words of this statement, "in a variety of life situations."

These two commission reports, directly concerned with the teaching of mathematics, both subscribe to the importance of utilizing a variety of life situations in order to clarify, and to transfer to a life-like situation, the kind of thinking characterizing a geometric proposition. Does the geometry teacher need more authoritative encouragement?

Now, what does a person do who thinks critically? This is a first step in creating an evaluation instrument to measure such an intangible objective as critical thinking, or critical judgment. The fifteenth yearbook of the National Council of Teachers of Mathematics[7] provides a characterization of what a person does who thinks critically.

(1) To recognize and formulate the assumptions underlying an argument.
(2) To recognize terms that require precise definitions.
(3) To organize statements in a coherent logical sequence.
(4) To recognize the proposition under discussion and to realize when a conclusion has been reached.
(5) To discover common flaws not only in reasoning in mathematical and related fields, but in areas inviting emotional bias or requiring propaganda analysis.
(6) To recognize a logical structure or plan of an extended series of propositions or a related group of discussions.

This above group of six characteristics of "what a person does who thinks critically" is not unique, or perhaps even complete. For purpose of discussion they will suffice to indicate how a test can be used to give at least a partial answer to, "what a person does who thinks critically?" Hackman and Ullsvik have chosen to label their test, "Critical Judgment," for it is concerned with making judgments rather than with creation of logical arguments. This test consists of three parts, Judging Conclusions, The Meaning of Terms, and Appraisal of the Evidence.

"Judging Conclusions" attempts to provide a measure of characteristic number 4, "To recognize the proposition under discussion and to realize when a conclusion has been reached." The following two problems give evidence as to a method for measuring this characteristic:

Problem I.
Information:
All freshmen wear green caps.
John is a freshman.
Conclusion:
John wears a green cap.
Problem XXI.

[7] *Ibid.*, p. 67.

Information:
Only persons under 18 years of age are admitted to the museum free of charge.
Everyone must go to school until he is 16 years of age.
George is admitted free of charge to the museum.
Bill is three years younger than George.
Conclusions:
44. Bill is admitted free of charge to the museum.
48. George is more than 18 years of age.

The conclusion of Problem I is evidently "acceptable," and if the student reasons correctly, he will indicate his decision by placing a checkmark in column A on the A, B, C, D, E column IBM answer sheet, that the conclusion must be accepted on the basis of the given information. But reasoning is more difficult in an involved situation such as Problem XXI. Here, the conclusion, "Bill is admitted free of charge to the museum," can neither be accepted on the basis of the given information, nor can the conclusion be rejected. If the student reasons correctly, he places a check in column C, indicating that there is insufficient evidence for the logical acceptance or rejection of this conclusion. Item number 48 gives a conclusion which can be rejected, because the given information supports the conclusion that George is *not* more than 18 years of age. This decision can be indicated by placing a mark in column B.

Part II of the test of Critical Judgment is called "Meaning of Terms." It attempts to provide a measure of characteristic number 2, "To recognize terms that require precise definitions." Two problems of Part II are given below:

Problem I.
The class in civics was preparing to study a unit on "Laws Pertaining to Motor Vehicles." The teacher asked each student to write a definition of a motor vehicle. The following definitions were written by two members of the class.
Definitions:
A. A motor vehicle is any device on wheels or tracks which is propelled by a motor or engine.
B. A motor vehicle is any device propelled by itself and usually driven on a public street or highway.
Descriptions:
61. An ordinary bicycle.
62. A power lawn mower.
Problem VI.
If an American were to visit England, he would find that his idea of a warehouse is entirely different than that of the Englishman. The following definitions are the ones commonly used in the United States and England.
Definitions:
A. A warehouse is a building in which manufactured products are stored instead of being offered for immediate sale.
B. A warehouse is any store whose merchandise is offered for immediate sale either to the consumer or to other stores.
Descriptions:
112. The large building in which Kellogg Company stores corn before it is

made into a breakfast food.

115. The Excello Tool Company building where all kinds of tools may be purchased by retail store owners.

Description 61, "An ordinary bicycle," will not fit either definition A or definition B of Problem I, and the student should place a mark in column C. "A power lawn mower," given in item 62, fits definition A but does not fit definition B, because a power lawn mower is not usually driven on a public street or highway. Thus, the student should place a mark in column A opposite item 62. Problem VI is more difficult. The description given in item 112 should be marked in column C, because the description given in item 112 doesn't fit either definition A or definition B. The description given in item 115 does fit definition B, and a check should be placed in column B opposite this item.

The third part of the test, "Appraisal of the Evidence," gives a measure of characteristic number 5, "To discover flaws not only in reasoning in mathematical and related fields, but in areas inviting emotional bias or requiring propaganda analysis." Because this characteristic is more difficult to measure, a scheme for recording the students' decisions must necessarily be more involved. Two problems of this third part are given below:

Problem I.

The new watchman noticed a big black sedan with the motor running parked back of the Peterson and Johnson Jewelry Store. Upon investigation he found a man dressed in overalls trying one key after another in an effort to unlock the back door of the store. The night watchman promptly took the man in custody concluding that *he was a burglar.*

Statements:

154. The night watchman was new on the job and perhaps would not recognize the owners of the store.

157. The man was very angry when the night watchman took him to the police station.

163. A suspicious looking character driving a black sedan had been reported to the police earlier in the evening.

Problem V.

The following statement appeared in an advertisement:

"Sally Suhr could hardly believe it. The pain that had tortured and crippled her was gone! How lucky for her; she tried Nideme. The thousands of unfortunates like her may now use the formula known as Nideme, for it is readily available."

Mrs. Smith who was suffering from arthritis decided after reading this advertisement that *if she took Nideme her arthritis would be cured.*

Statements:

212. Nideme is more expensive than aspirin.

215. Nideme contains a narcotic which relieves pain but does not cure the cause of the pain.

218. Nideme will produce similar results for Mrs. Smith as it did for Sally.

Problem I is to be evaluated in terms of statements which should lead one to accept the underlined conclusion, "*he was a burglar*"; to reject this conclusion; or to indicate the statements are irrelevant

to this conclusion. To indicate relative potency of arguments, the student is asked to choose which two of the 15 statements are most crucial in leading one to accept the underlined conclusion, and which two statements are most crucial in leading one to reject the conclusion.

Item 154 in Problem I should lead one to reject the conclusion, and because it is one of the two items considered most crucial in rejecting the conclusion, checks are placed in columns B and E. Item number 157 is irrelevant to the acceptance or rejection of the conclusion and, a check should be placed in column C. Item 163 should lead one to accept the underlined conclusion, and because it is one of the two items considered most crucial in the acceptance of the conclusion, checks are placed in columns A and D. Because item 212 in Problem V is irrelevant to the conclusion a check is placed in column C. Statement number 215 should lead one to reject the underlined conclusion, and statement 218 should lead one to accept the conclusion. Since both of these items are among those considered most crucial in the rejection or acceptance of the conclusion, checks are also placed in columns E and D in addition to checks in columns B and A.

This test of Critical Judgment is yet in an experimental stage. Further investigation will reveal its relevance to other measures, such as scores secured on the conventional intelligence tests. Some experimental evidence indicates, that whatever this test does measure it can be taught for by the teacher of plane geometry. This is consistent with investigation made by Fawcett,[8] Ulmer,[9] and Gadske[10] who provide evidence that plane geometry can be used as a media for the improvement in the ability to think critically, or to make critical judgments. And what's more, the studies indicate that the understanding of traditional plane geometry is at least retained by the "critical thinking" emphasis.

A recent publication by the National Association of Secondary School Principals entitled, "Imperative Needs of Youth of Secondary-School Age,"[11] is of importance to all persons concerned with secondary school curriculum building. Imperative need number 10 is given as: "All youth need to grow in their ability to think rationally, to express their thoughts clearly, and to read and listen with understanding." This need should prove a challenge to teachers of

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[8] Harold P. Fawcett, *The Nature of Proof*, The Thirteenth Yearbook of the National Council of Teachers of Mathematics (Bureau of Publications, Teachers College, Columbia University, New York City, 1938).

[9] Gilbert Ulmer, "Teaching Geometry to Cultivate Reflective Thinking: An Experimental Study with 1239 High School Pupils," *Journal of Experimental Education*, Vol. 8 (September 1939), p. 25.

[10] Edward Richard Gadske, "Demonstrative Geometry as a Means for Improving Critical Thinking," Unpublished Doctor's Dissertation, (Northwestern University, June 1940).

[11] *The Imperative Needs of Youth of Secondary-School Age*, Bulletin of National Association of Secondary-School Principals, Washington, D. C., March 1947.

geometry. The Association of Secondary School Principals has accepted this as an imperative need of youth; studies indicate that geometry can help meet this need; and the Harvard Report accepts geometry as one of the best media for meeting such a need. Such influences, supplemented by Commission Reports, should encourage geometry teachers to include in their teaching and testing some indication of their acceptance of this imperative need.

Yet, it is disconcerting to examine the popular texts of plane geometry. These texts do not provide the busy teacher with the kind of resource material necessary to sponsor the kind of classroom experiences which will improve critical thinking. Some texts give little indication that plane geometry has any contribution to make toward the teaching of critical thinking in nongeometric areas. The fault cannot be entirely placed upon the authors and publishers of texts, for many secondary teachers are not giving the publishers the support to indicate that such an adventure would be financially feasible. Textbook publishers are not anxious for profitless pioneering. If teachers would support publications that do attempt to provide resource material for improvement of critical thinking through the media of plane geometry, publishers will be more ready to pioneer.

How far apart are the objectives accepted by teachers of geometry and imperative need number ten? Repeated discussions with geometry teachers indicate that agreement is not forced, for teachers of geometry readily give verbal acceptance that logical or critical thinking is a primary objective. Yet, few teachers can illustrate any methods used to directly teach for this objective. It is evident that at present a hiatus exists between what the teachers of geometry profess as their primary objective, and the objectives which determine the pupil experiences they sponsor. This hiatus can be easily verified by classroom visitation, examination of the popular textbooks, and the tests used to measure what the geometry teacher is teaching for.

The tests used by the teacher are important, because pupils tend to learn what the teacher thinks is important enough to test for. Because the teacher is the director of the classroom learning experiences, the students "learn the teacher." His direction determines the relative importance of "critical thinking" among other objectives for teaching of plane geometry. Studies[12] indicate that the type of examination expected determines the kind of preparation made by the student. The "essay type" test encourages more effective learning preparation, and the "true-false" test encourages search for fragmentary-learning. If the kind of test determines the kind of learning,

[12] George Meyer, "The Essay Type Examination," *American School Board Journal*, December 1934, p. 17. Edward S. Jones, "The Relationship of Examinations and Instructions," *Proceedings*, 1936. Institute for Administrative Officers of Higher Institutions. (Chicago: University of Chicago Press, 1936) pp. 190–202.

surely the content of the test determine what is to be learned.

Thus, if a teacher of geometry who does not make an attempt to provide some measure for critical thinking, or critical judgment, not only does he not know whether or not the deductive thinking of geometry will transfer to a non-geometric situation, but the students will rarely consider it important enough to learn. What the teacher tests for, the student accepts as being important to learn for.

Teachers do not test for what they do not intentionally teach; for such testing would be meaningless. Yet, teachers indicate they want to teach for critical thinking, but tests of this objective are not readily available, and they are difficult to construct. This motivated Mr. Hackman and the author to provide a measure of critical thinking. This test may be used to motivate students to improve their ability to think critically in a non-geometric situation, and to determine whether or not there is transfer of the kind of deductive thinking characterizing Euclidean geometry into a more life-like, non-geometric situation. There is no need to discard any of the traditional values of plane geometry, but a "critical thinking" approach will stress the important geometric understandings and include a justification for teaching of plane geometry for general education.

PALOMAR AND PHOTOGRAPHY TEAM UP

Even the power of a million human eyes falls short of that of the new Hale Telescope atop Mt. Palomar in California.

The 200-inch telescope is really a huge camera—the world's biggest—and it has the strength which photography alone can give it.

In theory, the "big eye" has the light-gathering power of a million human ones.

Actually, the telescope is far better than this would suggest.

Why? Because the photographic plates used in the telescope:

Can be exposed for long times—hours if needed—to catch light human eyes would never see;

Make lasting records;

Provide "observations" for many people to see and study.

Kodak is now making special photoplates for use in the 48-inch Schmidt telescope, which will work in partnership with the 200-incher at Palomar.

Other Kodak plates will be used in the Hale telescope when it gets into operation in future months.

The first five-year task for the Schmidt, or "Big S," will be to map the universe.

The main use of the Hale telescope will be to collect the faint light from very distant stars. Its "range" is a billion light years. A light year is the distance light travels in one year at 186,000 miles a second—or about six trillion miles.

Micrographic camera offers a positive means of identifying and recording diamonds and some other transparent gemstones. This improved instrument for making photomicrographs records not only the characteristic so-called inclusions in the stone, which are as distinctive as fingerprints, but the stones's complete description.

DEMONSTRATIONS FOR GENERAL CHEMISTRY

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The following demonstrations have been of great help in getting certain principles across to students of general chemistry. They involve apparatus that can be set up and kept from year to year. The materials are inexpensive and in most cases can be taken from regular department supplies.

The principle of surface tension can be quickly demonstrated with the apparatus shown in Figure 1. The device can be clamped to a

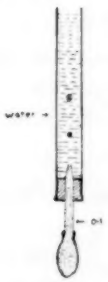

FIG. 1. To demonstrate surface tension.

stand and after use be set aside until needed again. The dropper should be filled with a heavy dark oil such as motor oil so that the rising sphere-like masses can be easily seen by students. This makes

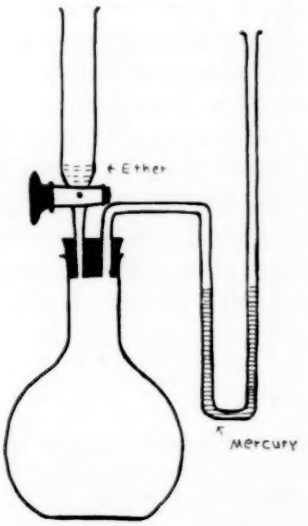

FIG. 2. To show vapor pressure.

an excellent demonstration to go along with a discussion dealing with immiscible liquids and emulsions. The glass tube should be of such a length that the oil drop can be followed for some time. Slight pressure on the bulb will eject a few drops at a time. The oil layer on the top of the water will prevent evaporation.

If there is a burette handy from which the top has been broken it can be converted into an apparatus for easily demonstrating the vapor pressure of a liquid such as ether. This apparatus is shown in Figure 2. A pinch-clamp arrangement may be substituted for the converted burette. Colored water may be substituted for the mercury; but if this is done the open end of the gauge should be made much longer. The apparatus is operated by letting a few drops of the ether fall into the flask and then quickly closing the stopcock. As the liquid evaporates the pressure will increase rapidly.

A very interesting demonstration of the combustible property of powdered starch can be made, as shown in Figure 3, with the aid of a

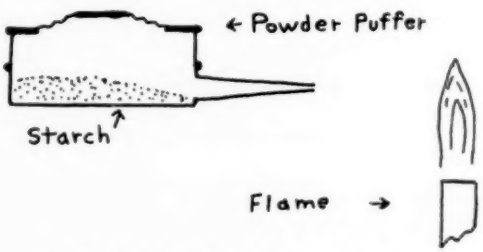

FIG. 3. Powdered starch is combustible.

simple powder puffer. The makers of Black Flag dusting powder has one on the market that is usually on sale at stores including the five and ten cent stores which sell such materials. Dry corn starch placed in the container so that the opening is not covered will give a suitable puff of dust. If the device is operated with a quick squeeze a rather loud spurt of burning starch will appear on the opposite side of the burner. Needless to say, it should be operated pointing away from all observers. This is excellent along with a discussion of powdered fuels. Some iron filings mixed with the starch also makes an interesting demonstration.

Wise men have always looked in amazement at the wonderful orderliness of nature and then recognized their own ignorance and have been content to stand in silence and reverence before Him repeating with the psalmist: "The fool hath said in his heart, there is no God."

—ROBERT A. MILLIKAN

A MODIFICATION OF AN ELEMENTARY EXPERIMENT ON SIMPLE HARMONIC MOTION

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Part of the general laboratory (elementary) procedure in an experiment on S.H.M. (e.g., the period of a vibrating coil spring) consists of setting the spring into vertical oscillation with a suitable mass attached and taking the time of a number of vibrations. The period thus determined is compared with the calculated theoretical period given by the familiar expression

$$T=2\pi\sqrt{\frac{m+m_0}{f/d}} \quad \text{where} \quad m_0=1/3 \text{ mass of spring}^* \quad \text{and} \quad f/d=\text{force constant of spring.}$$

The writer wishes to propose a modification of this procedure.

1. Measure the *approximate* period by taking the time of a number of vibrations. Call this period T_1.
2. Set the system into vibration again and start timing at some *defined* position. *One does not need to count the oscillations.* Let the vibrations continue for a time which is *very long* compared to that used in (1). Stop timing at the same defined position. Let the elapsed time be t seconds.
3. Divide this time t by the approximate period T_1; call the quotient n'. This number will, in general, not be an integer. However, if we have stopped counting at the same defined position at which we started we know the number of vibrations to be integral. Hence, take the integer n nearest to n', divide the total time t by n''; the result is a second approximation T_2. The extension of the method is obvious.

Let Δt be the maximum uncertainty in any single time determination (e.g., $\Delta t=0.2$ sec with an *ordinary stopwatch*). Count n_1 vibrations in time t_1. Then

$$T_1=\frac{t_1}{n_1} \quad \text{and} \quad \Delta T_1=\frac{\Delta t}{n_1}$$

whence

$$\frac{\Delta T_1}{T_1}=\frac{\Delta t}{t_1}=\frac{\epsilon}{n_1} \quad \text{where} \quad \epsilon=\frac{\Delta t}{T_1}.$$

* For a truncated conical spring, smaller end fixed, load hung on larger end.

Now let t_2 be observed corresponding to some *integral but uncounted* number of vibrations n_2. Then

$$n_2=\frac{t_2}{T_1} \quad \text{and} \quad \Delta n_2=\frac{\Delta t}{T_1}\pm\frac{t_2}{T_1^2}\Delta T_1$$

where, to be on the safe side, the plus sign must be used. Then

$$|\Delta n_2| =\epsilon+n_2\frac{\epsilon}{n_1}=\epsilon\left(1+\frac{n_2}{n_1}\right).$$

To be certain of n_2, $|\Delta n_2|<\frac{1}{2}$, and to be a useful procedure, $n_2>n_1$. Accordingly, $\epsilon<\frac{1}{4}$ is the necessary criterion as to whether the series can be extended.

We illustrate with an example:

Let us time with an ordinary stopwatch an oscillation where the period is 0.6 sec. Then, for this case, $\Delta t/T=0.2/0.6=\frac{1}{3}$. Suppose that 20 vibrations are timed in 12.0 seconds. As far as can be known from a single observation this time is 12.0 ± 0.2 sec. This yields a period of $0.60\pm.01$ sec. Now let a second timing be made in which the watch reads 11.8 sec., the number of vibrations being integral but uncounted. This time may be accounted for

as

(1) $$20\times.59=11.8 \text{ sec.}$$

or

(2) $$(19\times.61)+0.2=11.8 \text{ sec.}$$

There is, therefore, no clear certainty that the second number was 20 rather than 19.

The question arises: Will increasing the number *originally* counted yield more reliable information? The answer is NO. For, suppose we counted 50 vibrations in 30.0 sec. Then $T=0.600\pm.004$ sec. A second timing reads 30.2 sec. This may be accounted for

as

(1) $$50\times.604=30.2 \text{ sec.}$$

or

(2) $$(51\times.596)-0.2=30.2 \text{ sec.}$$

If, on the other hand, an electric timer is used, Δt may well be of the order of $\frac{1}{10}$ sec. Accordingly $\epsilon=\frac{1}{10}$ for the case cited, and a time very long compared to that used in (1), say 3 times as long, yields reliable results.

A FOURTH-FIFTH GRADE LESSON WITH ELECTRICITY: DEMONSTRATING A USE OF SOUND FILM

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How may teachers of elementary science help children accept the sound film as part of their thinking? In lessons that stress the process values of elementary science, how do children react to sound films? As children assimilate the elementary science sound film, what are the teacher's problems? These questions are asked by students of teaching and by teachers-in-service. These are the questions which directed the study reported in this article.

A lesson with children was used as source of data and conclusions. This lesson was taught by the author on the stage of the auditorium of the New Jersey State Teachers College at Glassboro. Two hundred eighty teachers observed the lesson. The occasion was the Third Annual Meeting of the South Jersey Audio-Visual Aids Association on May 6, 1948.[1] The Association wished to see a sound film used in science instruction. Six public school administrators from New Jersey acted as a panel of critics.[2] At the conclusion of the lesson, after the children left the stage, this panel questioned and discussed with teacher and audience.

Seventeen children comprised the demonstration group. They were part of the Fourth and Fifth Grade classes[3] of the Laboratory School of the New Jersey State Teachers College at Glassboro. Participation by the children was voluntary since the lesson, of fifty minutes duration, began at five o'clock in the afternoon. The range in I.Q. was from 86–145. The range in C.A. was from 8:8–11:4. All of the children in this demonstration group had received instruction in science from the author (hereafter referred to as the "teacher"), once a week for a year. Some of these children had received instruction in science from the teacher, once a week, for two years. The classroom teacher had instructed these children in science, for two years, as part of the classes in social studies.

After the audience had assembled, the teacher conducted the children to their chairs on the stage. The children, seated at the right

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[1] Advisor: Miss Anna K. Garretson, Assistant Professor of Education, New Jersey State Teachers College at Glassboro.

[2] Clarence Boyer, Superintendent of Schools, Boonton, Director of Audio-Visual Instruction for Morris County; Albert Bean, Superintendent of Schools, Camden County; Willard B. Mathews, Superintendent of Schools, Cape May County; J. Harvey Rodgers, Superintendent of Schools, Gloucester County; Mason A. Stratton, Superintendent of Schools, Mays Landing; Lawrence E. Winchell, Superintendent of Schools, Cumberland County.

[3] Taught by Miss Clella Finster, New Jersey State Teachers College at Glassboro.

of the audience, faced the teacher. The teacher, at the left of the audience, faced the children. Table, blackboard and motion picture screen were near the teacher.

Teacher Preparation

Formulation of the lesson necessitated consideration of four major problems. Some of these problems are occasioned by use of audio-visual aids.[4,5] They involved selection of an area of science, determination of the values desired from the lesson, determination of the manner of use of the film and choice of the film. They were considered in the order as given.

The area was selected after consultation with the classroom teacher. The teacher asked the classroom teacher concerning the science that she had taught to the children and the nature of their interests. Thus, two criteria were applied: maximum interest and minimum acquaintance. This consultation resulted in selection of electricity as the instructional area.

The author is interested, particularly, in the thought processes of children.[6] It seemed that a lesson with electricity might reveal and demonstrate important features of reflective thinking. It seemed that such a lesson might bring into relief some contribution of process (thinking) to product (factual learning). Accordingly, the lesson was planned to emphasize values implied in the thinking of these children.[7]

Having determined the value-goals of the film, the manner of use was considered. A film functions in reflective thinking in three ways. It initiates problems, supplies information, and facilitates application of principles. The teacher decided to use the film as a source of information.

But, as source of information, the film admits of further analysis. Such information may contribute to formulation of hypotheses, formulation of conclusions or application of conclusion. The teacher decided to use the film as a source of information for formulation of conclusion.

Tentative choice of film was made from listings in the Section on Electricity of the Educational Film Guide.[8] This source described the film as follows:

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[4] Carmichael, O. C., "Some Educational Frontiers," *School and Society*, Vol. 68, No. 1761, September 25, 1948, pp. 193–196.

[5] Mallinson, G. G. and Gjerde, W. C., "Motion Pictures for High School Science," School Science and Mathematics, Vol. XLVIII, Oct. 1948, No. 423, pp. 525–534.

[6] Haupt, George W., "A Neglected Factor in the Teaching of Elementary Science," *Science Education*, January 1939, Vol. 23, No. 1, pp. 31–34.

———, "First Grade Concepts of the Moon," *Science Education*, Vol. 32, No. 4, October 1948, pp. 258–262.

[7] Maier, N. R. F., "Reasoning in Children," *Journal of Comparative Psychology*, 1936, Vol. 21, pp. 357–366.

[8] *Educational Film Guide*, Annual Edition, Sept. 1947, H. W. Wilson Company, New York, 1947.

FLOW OF ELECTRICITY. 10 Minutes. Describes in a simple and straightforward manner, the flow of electricity by means of a simple demonstration in a home situation. Animation is used to demonstrate the flow of electricity through the circuit. Young American Films, Inc. 18 East 41st Street. New York 17. Advisor: Dr. Gerald S. Craig. Teachers College. Columbia University. New York City.

Final selection of the film was made after three showings for the teacher. The first run was for the purpose of obtaining an overview. At the second run, the film was studied in conjunction with the descriptive folder that accompanied the film. At the third run the film and descriptive folder were studied in conjunction with the teacher's plan of the lesson. Instructional results seemed to justify the time and care used in the three showings.[9,10]

PLAN OF THE LESSON

For guidance in observation of the lesson, and as basis for discussion, the author distributed an outline as the observers assembled. Neither children nor classroom teacher read the outline until after the lesson. The outline follows:

Purposes

1. To interpret children's experiences with electricity. (Product value).
2. To utilize children's thinking in a complete act of thought. (Process value).

Procedure

1. Presentation of experiment. To precipitate and identify problem and to provide data for tentative solution.
2. Derivation of tentative solution.
3. Showing of film. To provide data for conclusion.
4. Derivation of conclusion.
5. Presentation of experiment. To provide data for application and extension of conclusion.
6. Application and extension of conclusion.

THE LESSON

This description includes teacher remarks, pupil remarks and comments concerning the lesson. The purpose is to emphasize a thought movement wherein development is primary and permanence is secondary. It is a sketch of some of the steps in reasoning as they occurred in an elementary science lesson. It describes a utilization of

[9] Keele, V. S., "Audio-visual Problems and Suggestions," *The Science Teacher*, Vol. XV, No. 4, Dec. 1948, pp. 167–169.

[10] Hoban, C. F., "Film Evaluation in Practice," *Educational Screen*, Vol. XXVII, No. 2, Feb. 1948, pp. 63–65, 71.

content as means rather than end—a contribution of product to process.

The (T) indicates teacher remarks. The (C) indicates pupil remarks. Comments are indicated thus ( ). The remarks and comments that are selected for this presentation are those that seem to mark, most distinctly, the course of the children's thinking from problem to conclusion.

1. *Presentation of Experiment. Exploration of Problem*[11]

(T) Boys and girls, I am going to show you an experiment. This is an experiment with electricity. I will do the experiment and you watch what happens. Then, see if you can tell why it happens.

(T) First of all, let's make sure that you understand what we have to work with. Here is a drinking glass. I fill the glass with water.

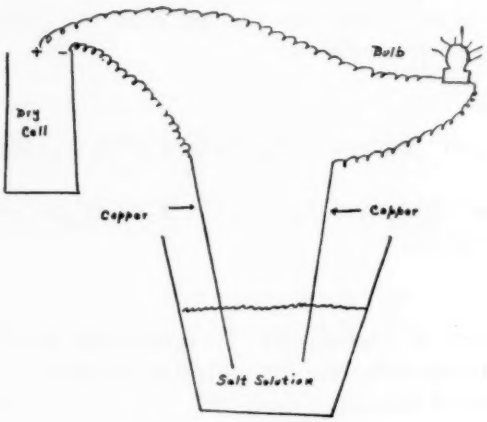

FIG. 1 Wiring Diagram

The water is just plain Glassboro water (child comes to the desk and examines the water). Here are two strips of copper. Do you know what copper is? (Children name objects, including wire). I put the strips of copper in water; this way. Notice that the pieces of copper do not touch each other. They are apart. But, is there anything touching the pieces of copper? (Children say that the water touches both pieces of copper). (T) Now, I take the copper strips from the water.

(T) Let's connect the flashlight bulb, the dry cell and the copper strips all together. How can I connect them all together? (C) Make a circuit. (T) How can we make a circuit? (C) Use the binding posts. (Discussion of plus and minus binding posts.) (T) All right. I run a

[11] The discussion between teacher and learners, in this Exploration, indicates that the most significant features of observation are the *relations* between observed facts rather than the facts taken singly.

wire this way, and this way etc. Now I have a circuit. (Diagram is placed on the blackboard and the hook-up on the desk is examined by the children.)

(T) Do you understand how the copper strips, dry cell and bulb are connected? (Discussion.) (C) Touch the copper strips together. (They are contacted and the bulb lights.) (Animated discussion among the children.)

(T) Now (displaying hook-up) I put the copper strips in the water but I keep the strips apart. The strips will not touch each other. What will happen? (C) The bulb will light. No, it won't. There is a circuit made by the water and so the bulb will light. It won't light; you have to have copper etc. etc.

(T) I push the copper strips into the water. See. The bulb does not light. (C) Push the strips together. (The bulb lights.) (C) Keep the strips real near, but not touching. (The bulb does not light. The class seems perplexed.)

(T) Watch, boys and girls. Here is some salt—ordinary table salt. I take a pinch of the salt and throw it into the water. Look. (The bulb lights.) (C) Ah. (Other exclamations of surprise and delight.)

1A. Definition of the Problem[12]

The children talked with each other, and with the teacher, about the light. Their remarks concerned the effects of the salt. (C) How bright the light got. The light does not grow dim. The light does not flicker. (After several minutes of such discussion, the teacher stated the problem). (T) Why does the bulb light when the salt is dissolved in the water?

2. Derivation of Tentative Solutions. Hypotheses[13]

The children gave reasons as follows:

I. The salt coats the copper with something.
II. The salt makes electricity.
III. The salt is a chemical and chemicals make electricity.
IV. The salt makes bubbles and bubbles have something to do with it.
V. Electricity goes through the wires and there is a circuit.[14]

These explanations were written on the blackboard as they were given. The children were encouraged to state their ideas "even though they might turn out to be wrong." There was no discussion

[12] Northrop, F. S. C., *The Logic of the Sciences and the Humanities*, 1948. Macmillan. Chapter I. The Initiation of Inquiry.

[13] Three tests of observation are: (I) Agreement of competent observers; (II) Agreement of observations with each other and (III) Use in solving problems. This lesson developed, in the Derivation of Hypotheses, only the last of the three tests.

[14] Note how these hypotheses range from statements of observed facts to inferences from observed facts.

of the statements and the lesson did not proceed until the children could give no further explanations. When the limit of children's tentative solutions was reached, the implications were explored.

2A. Exploration of Hypotheses

Here, values of judgment are demonstrated. Which are the better explanations? Why? Which is the best explanation? Why? Can the children elaborate their hypotheses? Can they find facts to discredit their hypotheses? In weighing the relevancy of their thoughts, children derive considerable intellectual satisfaction. Mental growth is not measured, always, in terms of correct answers. Rational choice is a function of thought.[15]

(T) You say that the salt coats the copper with something. With what does the salt coat the copper? (C) It looks green. (T) What is on the copper? (No progress.) (T) How does the salt coat the copper? (No reply.) (T) Suppose the salt does coat the copper, so what? How can that make electricity? (No progress.) (T) Well, boys and girls, your answers show that you have observed what happened. But, do you agree that your answer does not explain why the bulb lights? (The children admit that their "coating" explanation has not given a reason for the illumination of the bulb.)

(T) Next, you say that the salt makes electricity. How does the salt make electricity? Why doesn't the bulb light when I put some salt (dry) against it? This way. Does salt make electricity in the salt shakers at home? (The children made no reply to these questions.) (This statement, that "salt makes electricity," is a stage simpler than the next hypothesis.)

(T) Now, what about your idea that salt is a chemical and that chemicals make electricity? (There was discussion of chemicals. Salt was called a chemical. Acids were discussed, as well as other chemicals that make electricity. The class insisted that chemicals make electricity.) (T) But, how do chemicals make electricity? (The children stated no facts that could be used to advance their explanation of production of electricity by chemicals.)

(T) Well, you say that the salt makes bubbles and that the bubbles have something to do with it. What do the bubbles have to do with the light coming on? (C) It looks as if there are bubbles only on one of the strips. No; there must be as many bubbles on the other strip. Shake the glass of water. Look, the bubbles come to the top. (T) What do the bubbles have to do with the light? (The children only repeat that bubbles and salt have something to do with the glow of the bulb.)

[15] Especially when we apply the criterion of simplicity. Which hypothesis brings the greatest simplicity to our view of the happening?

(T) Boys and girls, your last idea is that electricity goes through the wires and so there is a circuit. How do you know that electricity goes through the wires? (C) The bulb lights. (T) Would the bulb light if electricity did not go through the wires? (C) No. (T) What is a circuit? (C) Everything is connected. (T) How does the salt make the electricity go through the circuit? (The children advance no further than the initial statement that "electricity goes through the wires and produces a circuit".)

Thus, the children have explored their explanations and they realize a lack of knowledge. The task of the teacher is to provide data. As stated, the lesson was planned to utilize a film as source of information by aid of which the children could reformulate and advance their explanations. The film was selected to supply, as nearly as possible, the key knowledges that the children needed.

3. Presentation of Data. The Film

Two projectors and two films were used. One projector was placed in the wing of the stage, back of the children, and focussed upon a small screen which the children faced. The second projector, placed at the rear of the auditorium, was focussed upon a large screen which the audience faced. When it was drawn, the large screen separated audience and children. The use of two projectors and two screens aided the children's concentration in this type of lesson.

The film contributed to three objectives which were stated in the accompanying "Teacher's Guide." These were: to present, through simple demonstration the factors which affect the flow of electricity through a simple circuit; to introduce the electron theory; to show the application of a simple circuit in a home situation. Summaries throughout the film helped to identify and emphasize the objectives.

Several concepts, discussed by the children prior to the projection, were developed in the film. These concepts were: Terminal, Electron, Flow of Electrons and Circuit. The film proved especially valuable in clarification and extension of knowledges that were initiated by the other learning activities of the lesson.

4. Derivation of Conclusion

At the completion of the film the teacher asked the lesson-question again. The question was stated as at the beginning of the lesson. Why does the bulb light when salt is dissolved in the water? Immediately, a number of children responded with statements that were adequate as conclusions. A typical statement was: "The bulb lights when salt dissolves in the water because, then, the salt splits into plus and minus charges. These plus and minus charges complete a circuit between the dry cell and the bulb." Other responses ranged

near the foregoing in completeness and accuracy. This time, the children answered the lesson-question in the form of conclusions to which the film had contributed a portion of the key knowledges.

5. Presentation of Experiment. Data for Application and Extension of Conclusion

The Derivation of Conclusion was followed by an illustrative experiment. On the lesson outline it was called "Experiment." The purposes were to demonstrate one of the important functions of experiment in thinking and to assist the children with clarification, application and extension of learnings derived from the film. This illustrative experiment was in the form of an analogy.

A five cent piece and a one cent piece were shown to the children. The two coins were held together tightly and the children were told that the combination represented a molecule of salt. (T) What is this molecule of salt made of? (C) Two parts, a nickel and a penny. (The two coins, thus pinched together, were released from the fingers as they fell into the water. They separated at the bottom of the glass.) (T) Now the molecule has formed ions—an ion of sodium and an ion of chlorine. Now the water will conduct electricity. The nickel is a plus sodium ion and the penny is a minus chlorine ion.

6. Application and Extension of Conclusion

Again, the teacher asked the lesson-question. (T) Why does the bulb light when salt is dissolved in the water? The children's replies may be summarized as follows: "The salt is made up of plus and minus charges of electricity. Before the salt dissolves, the plus and minus charges are not active. After the salt dissolves, the plus and minus charges are active and current flows in the circuit." The children's replies to details of the lesson question evidenced understanding of principles underlying the conduction of current in the bulb circuit.

Briefly, the process of electroplating was explained. The children were interested in the plating of table ware with silver. They asked about chrome plating of automobile bumpers and household hardware. They wanted to know if all metals could be used in electroplating. They asked what takes the place of the salt water in an electroplating bath and, in such a bath, which poles are plus and minus. The explanation of electroplating permitted by this stage of the lesson helped to apply and extend the children's understanding of important facts and principles relative to the flow of electricity.

We have let the idea of freedom under self respect go to seed in our colleges and are turning out too many hard-boiled, hard-hearted, hard-headed dumb-bells.
—WILLIAM ALLEN WHITE

A REPORT ON PROGRESS IN MATHEMATICS EDUCATION*

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INTRODUCTION

The members of this "Trends" or "Progress Committee" accepted their appointment in the late spring of 1948 with the knowledge that any one of several alternative definitions of their function and tasks would provide them with an interesting though extensive project. Our major objective has always been to gather and disseminate information concerning research projects, curriculum revisions, and, most particularly, classroom experiments in methods of presentation and in the organization of new courses and of thorough revisions of older courses. By this exchange of information we hope to encourage additional experimentation and a more vigorous mathematics instruction through the realization by every teacher that he may vary procedures, write new units, stimulate students to undertake new projects, invent new teaching aids, no matter where he is teaching nor for how long or short a time. "Others are doing it, let *us* try something and then let's swap ideas again," is the reaction for which we hope.

We began with a survey of the literature, seeking "trends." In our report we shall list these trends only briefly and with the chief object of pointing out needs for further study and clarification. This brief treatment of trends was settled upon because we found other surveys of this type in print or about to be published,[1] and because we came to feel that we could more profitably use our time to point out projects which are less publicized than those which have been so thoroughly worked over as to be established trends.

The second division of our report will be devoted to current problems and projects, to be followed by some news notes and current events relating to mathematics education abroad and to mathe-

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* A preliminary form of this report was submitted by the chairman, Phillip Jones, to the Mathematics Section of the Central Association of Science and Mathematics Teachers at its annual meeting on November 26, 1948, in Indianapolis.

[1] *The Review of Educational Research*, 18, October 1948, titled "The Natural Sciences and Mathematics" summarizes the literature in these fields for the past three years. It contains chapters titled: "Aims and Purposes," "Methods and Materials," "Measurement and Evaluation," "Teacher Education." This number is sold for $1.00 by the American Educational Research Association, 1201 Sixteenth Street, N.W., Washington 6, D. C.

In "What's Going on in Your School?", *The Mathematics Teacher*, 41, pp. 147–153, April 1948, Raleigh Schorling summarized the data gathered by a questionnaire published in *The Mathematics Teacher* for the Post-War Planning Commission of the National Council of Teachers of Mathematics.

Reeve, W. D. "Significant Trends in Secondary Mathematics," *School Science and Mathematics*, 49, pp. 229–236, March, 1949.

matics itself. We should like to recommend a continuation of this project. We have found it most interesting. We believe it could be helpful to others, but we have by no means been able to complete (it never can be *fully* completed, of course) or even to organize fully the project in the time and with the facilities available. In this connection and before going farther we wish to emphasize that our lengthy list of references is by no means complete nor has it been selected on the basis of a critical evaluation. We are merely attempting to cite representative discussions and to give credit where credit is due. It would be desirable for a later committee to be both more complete and more critical in its report.

Trends

The current slogan in the philosophy-psychology of mathematics instruction is "teaching for meaning" or "teaching for understanding." These phrases are, however, interpreted in considerably different fashions, and are correspondingly translated into teaching procedures at considerable variance with one another. The chief differences are between those who say we must teach for *social* meaning[2] and those who interpret meaning or understanding to apply to the *mathematical* processes and organization.[3] For the former group "teaching for meaning" implies much use of projects and units built around social-economic situations, fewer separate problems, a reduction in the number of items taught for mastery; for the latter group "teaching for meaning" requires more emphasis upon the structure and sequential nature of mathematics and upon the interconnections of mathematical topics. Of course, there is also a group of moderates which insists that we must teach for both types of meaning.[4] These conflicting interpretations point out a need for a clarification and standardization of terminology,[5] an examination of the classroom teaching implications of each philosophy, and then planned experimentation followed by careful evaluation.

Such evaluation will require the continued development of techniques for testing for items other than mere accumulation of information and mastery of techniques. Claims for the teaching of such qualities as understanding, appreciation, problem solving, logical

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[2] Wilson, G. M., "Social Utility Theory as Applied to Arithmetic—," *Journal of Educational Research*, 41, pp. 321–337, January, 1948.

[3] For a summary of the literature dealing with both sides of this question see H. E. Moses, Lucien Kinney, Chas. Purdy, Chapter II, "Aims and Purposes—," *Review of Educational Research*, 18, October, 1948. William A. Brownell is an outstanding advocate of teaching for mathematical meaning. See "The Place of Meaning in the Teaching of Arithmetic," *Elementary School Journal*, 47, pp. 256–265, January 1947.

[4] Mallory, Virgil S., "Meaning in the Junior High School," *The Mathematics Teacher*, 41, p. 251 ff., October 1948.

[5] Johnson, J. T., "What Do We Mean by Meaning in Arithmetic," *The Mathematics Teacher*, 41, pp. 362–367, December, 1948, discusses "Structural Meaning," "Functional [social] Meaning," "Operational Meaning" in concrete terms.

reasoning, and social meaning are merely glib phrases until the difficult task of analyzing them and testing the success of such teaching is pursued farther. Although this task is not new, its pursuit may be labeled a second "trend." There is an existing literature,[6] and just prior to the presentation of this report Dr. Bjarne R. Ullsvik discussed "An Attempt to Measure Critical Judgment" at this meeting. However, there is a continuing need for more thought, planning, and experimentation of this type if any phase of "teaching for meaning" is to have any meaning. An additional need for tests for guidance purposes will be noted later.

A third "trend" which also is accompanied by many unsolved problems is the development of courses to meet the demands of modern "general education." We will refer to the problem of such courses on the secondary level when we discuss the "double track" system. On the college level we find courses designed for this purpose ranging all the way from those emphasizing remedial work in elementary arithmetic, algebra, and geometry to those which are full of discussions of set theory, abstract algebra, and logic. Such a hiatus in course content reflects wide differences both in teaching objectives and in the previous preparation of the students and is accompanied by almost kaleidoscopic changes in the list of schools offering such courses. Kenneth Brown asks, "Is General Mathematics in College on Its Way Out?",[7] after having earlier raised the question "What Is General Mathematics?".[8] Though many schools have tried and discarded such courses, others are beginning anew. The University of Michigan is preparing to introduce such a new course to better meet the objectives of mathematics general education which were implied by a new set of graduation requirements. One such new requirement presents every literary college student with the option of a year either of mathematics or of philosophy. The problems of the content and methods to be used in such courses need more analyses and exchanges of experience before some agreement as to general objectives and procedures can be reached. There should also be a program of testing and evaluation in connection with such courses in order to have a better basis for discussions and agreements.

In an article "Effects of Revision of Junior College Mathematics," M. L. Hartung[9] suggests that one repercussion of such courses may

[6] Meader, Elsa M. and Eagle, Edwin, "Chapter V, Measurement and Evaluation in Mathematics and Science," *Review of Educational Research*, 18, October 1948.

Hartung, M. L. and Fawcett, H. P., "Measurement of Understanding in Secondary School Mathematics," *The National Society for the Study of Education*, 45th Yearbook, Pt. I, pp. 157–174. Chicago: The University of Chicago Press, 1946.

[7] Brown, Kenneth E., *The Mathematics Teacher*, 41, pp. 154–158, April 1948.

[8] Brown, Kenneth E., *loc. cit.*, 39, pp. 529–531, November 1946.

[9] Hartung, M. L., "Effects of Revision of Junior College Mathematics," *School Review*, 53, pp. 197–198, April 1945.

be to make revisions of the secondary school curriculum easier. This latter may also be one effect of "The Michigan College Agreement" whereby Michigan colleges agree to accept graduates of participating high schools "irrespective of the pattern" of their high school courses provided they are in the upper portion of their class scholastically and provided their principals recommend them. To become "participating" the high schools must agree to institute a testing, record keeping, self-evaluating and self-improving program within their own system.

Many of these college general mathematics courses lay considerable emphasis upon postulational procedures and a better understanding of the nature of mathematical systems and rigor.[10] There may be a trend to emphasize rigor and logic in secondary school algebra and arithmetic as well as in geometry. It is too early to call this a trend but there are several articles dealing with such problems.[11] It would be desirable to have more thought and experimentation along this line.

On the secondary level mathematics for general education is one phase of that which in this country has been called the "double track" program but which with characteristic caution is referred to as a "multi-lane" program in England. Schorling notes that although the idea of a "Consumer Mathematics" course for the upper high school grades was generally accepted by the schools replying to a questionnaire, less than one-quarter of them were doing anything about it.[12] The newly completed state curriculum study in Iowa recommends a course in consumer mathematics to all Iowa high schools. We cannot prove that the experience of Miss Emily Shoup of the Holland (Michigan) High School is typical, but it may indicate some of the problems of such a course. She notes that the 31 students in her new "Practical Mathematics" class range in I.Q. from 78 to 144 and in previous high school mathematics experience from 1 to 8 semesters. Eight of her class are "cooperative program" students doing part-time work in local stores and businesses. These latter have been used as "resource people" in connection with the combined "unit" and "project" approach which the nature of her class made seem desirable if not absolutely necessary.

Ninth grade general mathematics has been a common offering for years, but Schorling reports that teachers still don't like it. In Dear-

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[10] A discussion of an example is to be found in Northrop, E. P., "Mathematics in a Liberal Education," *The American Mathematical Monthly*, 52, pp. 132–137, March 1945.

[11] See Van Engen, H., "Logical approaches to $(-a)(-b)=ab$ and $x^0=1$," *The Mathematics Teacher*, 40, p. 182 ff., April 1947; Niessen, Abraham M., "The Extension of the Exponent Concept," SCHOOL SCIENCE AND MATHEMATICS, 48, pp. 605–610, November, 1948; and, for further references, the notes to Jones, Phillip S., "An Interesting Trend in the Teaching of Algebra," SCHOOL SCIENCE AND MATHEMATICS, 47, pp. 225–228, March 1947.

[12] Schorling, R., *loc. cit.*

born, (Michigan) schools one semester of this course is ***required*** of all ninth graders. In Flint (Michigan) a lower level course termed "Basic Mathematics" is required of all ninth graders (and originally of some from the upper grades) who fail to attain a score of 8.0 on the Schorling-Clark-Potter arithmetic test. Miss Marguerite M. Farmer of Flint Central High School, who not only helped to plan the course and to teach it but has also studied its effectiveness for several years, reports that some pupils enter high school without having had a passing grade in arithmetic since the third or fourth grade, and that in its first year (1944–45) the course even contained six pupils who had had a year of algebra and geometry, and twenty-two who had had a year of either algebra or general mathematics followed by a year of either commercial arithmetic or shop mathematics. Miss Farmer points out that since for such a group there was no interest in the course, little inclination to work, and no work nor study habits, the first teaching task was to change the students' attitude by showing them the utility of arithmetic, and convincing them simultaneously of their lack of competency, and of the possibility of their improvement. All of those items point out problems and diversities of practice which emphasize that the ninth grade general mathematics "track" is far from being smooth and clear. Eagle and Palmer[13] even question the desirability of a double track at all in the ninth grade.

Although Schorling and others warn that we must not be too complacent about the other track, the sequential courses, little is being done about them and the superior student. One exception is the interesting experiment Mary E. Albers and May V. Segol reported under the title "Enrichment for Superior Students in Algebra Classes."[14]

Enrichment materials, laboratory methods, the use of instruments and teaching aids, the writing of source units, the utilization of applications, are all representative of modern teaching trends and are frequent topics upon the programs of the workshops and institutes such as have been held recently at Duke, Ohio State, Northwestern, Wisconsin, and Illinois Universities. These techniques are useful with classes on both "tracks." There is still a need both to locate and to interest as well as to train the more able students who have been somewhat neglected. The emphasis noted above upon writing "source units" and the use of applications indicates an attempt to do something concrete and immediate to incorporate into daily teaching the philosophical and psychological principles of the need to show social

[13] Eagle, E. and Palmer, G. W., "Reactions to the National Council Second Report," *California Journal of Secondary Education*, 20, pp. 373–376, November, 1945.

[14] Albers, Mary E. and Segol, May V., "Enrichment for Superior Students in Algebra Classes," *Journal of Educational Research*, 40, pp. 481–495, March 1947.

utility for motivation and "meaning," the need to be concrete and to relate instructional material to the needs, interests, and experience of the students as well as attempts to individualize instruction and teach for "transfer." None of these are new principles but perhaps there is something new in the manner in which they are being included in teacher training programs.

Current Problems and Projects

One interesting phase of the emphasis upon applications and social utility is the occurrence of a variety of courses (and units) in which mathematics is taught largely in terms of its connections with some other field. We find, for example, courses in industrial mathematics, shop mathematics, drafting mathematics, business mathematics, mathematics for electricians and radio-men.[15] Hester Douthart of Newton, Iowa, is developing a mathematics course in conjunction with the school's industrial arts department.

Of the various projects and units designed to point out the personal and social functions of mathematics and to increase interest perhaps the most common are those related to the gathering and analysis of data. Humphrey Jackson's students' "Activity Planning Board of the Higher Arithmetic Classes" has organized political polls as well as pencil-selling "corporations" as joint projects of the ninth grade arithmetic classes.[16]

Rachel Fundingsland has developed units on Problem Solving and Statistics for her third semester algebra class at Grosse Pointe (Michigan) High School. She has used a similar unit with ninth graders. The latter built a unit around choosing a vocation. The older students developed their unit out of a discussion of "Preserving World Peace" and built it especially around "Human Relations." Among other things they listed anecdotes and all matter of hearsay "facts" about certain minority groups and then set out to gather, evaluate and interpret data about these groups. Any of their tabulated faults and criticisms for which they could not find valid evidence they then labeled as *prejudice*.

The reasons for the increasing interest in and emphasis on statistics are obvious to all who have observed the growth of polls (!), survey research, quality control, and the use of statistical procedures in business, agriculture, and the natural sciences. How much of what

[15] See for example Nodler, M., "Integrating Mathematics and Industrial Arts," *Industrial Arts and Vocational Education*, 37, pp. 215–218, June 1948; Waters, E. A., "Making Schools Effective for Improved Living III, C. Mathematical Unit on Clothing Used in a Junior High School Group," *National Association of Secondary School Principals Bulletin*, 32, pp. 47–53, May 1948; Mossman, E. L., "Mathematical Concepts through Social Studies," *California Journal of Secondary Education*, 22, pp. 473–476, December 1947.

[16] Jackson, Humphrey C., " 'POP' means Pierce's Pupil Opinion Poll," *The Clearing House*, 22, pp. 537–539, May 1948. A second article describing the activities of the Planning Board at the John D. Pierce Junior High School of Grosse Pointe, Michigan, will soon appear in the above journal.

sort of statistics should be a part of both secondary and collegiate general education is a problem concerning which there is still debate both here and abroad.[17]

A different type of data, physical or mechanical in nature, is gathered and used by Sheldon Myers' students in studying variation.[18] Here an effort is made to distinguish between inductive and deductive reasoning and to clarify the real relationship between mathematics and science, not merely to give the idea that scientists use mathematics and then drop the matter. Mr. Myers is developing his entire ninth grade mathematics course at the Ohio State University School this year from and out of such an initial approach. His final report on this latest venture should be interesting.

Viola Smith of Waterloo, Iowa, is working on a new unit dealing with an old topic, the conic sections.

A very interesting and thorough experiment in teaching methods is being conducted by Sisters Agnes Marie and Mary Edwards of the Holy Redeemer High School of Detroit. They are teaching Algebra and Geometry respectively using a "group work" procedure. They first built up in the class an understanding of both their objectives and their procedures. They now find more time for individualization of instruction and personal teacher contact with individual students as well as more pupil participation in the class through the utilization of the better students as leaders (not substitutes for the teacher) of small work groups which function for a part of many class periods. Carl Phelps had suggested a similar program earlier,[19] but Sisters Agnes Marie and Mary Edwards have really set up a comprehensive program.

The growing emphasis on general education in both high school and college parallels an increasing need for both scientists and scientifically literate citizens. This presents an increasingly complex guidance problem. We need to discover able students and guide adequate numbers of them into a strong and rapidly unfolding sequence of scientific and mathematical studies while at the same time providing the remaining students with the mathematical literacy which they need. To do this we not only need courses adjusted to the ability, interests, and previous training of the students, but we also need improved guidance information and techniques. Several colleges (e.g. University of Michigan, Ohio State University) are developing and using placement tests to help in the guidance of freshmen into

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[17] An interesting account of one teaching experiment in England is to be found in Brooks, B. C., "Incorporation of Statistics in a School Course," *The Mathematical Gazette*, 31, p. 211 ff., October 1947.

[18] Myers, Sheldon, Marks, James E., Reynolds, Jack, "Making Concrete Several Kinds of Variation in Algebra," SCHOOL SCIENCE AND MATHEMATICS, 48, pp. 639–646, November 1948.

[19] Phelps, Carl W., "Group Work in High School Mathematics," SCHOOL SCIENCE AND MATHEMATICS, 45, pp. 439–443, May, 1945.

the proper elementary mathematics courses. In some schools an elementary mathematics course is being required of all freshmen falling below a fixed minimum standard of proficiency.

Several groups have prepared pamphlets containing information about mathematics which should be widely known and used by mathematics teachers and all persons advising high school students. The most extensive is that prepared by the Commission on Post War Plans of the National Council of Teachers of Mathematics. A more specialized study showing the college curricula which have mathematical prerequisites at Michigan colleges has been published and distributed to high schools by a committee of the Michigan Section of the Mathematical Association of America.[20] A similar pamphlet for Indiana is being prepared by P. D. Edwards of Ball State Teachers College in Muncie. These studies are designed not to propagandize for mathematics nor to sell college preparatory mathematics for all students but rather to make available data which should be considered by college preparatory students in order to avoid later delays or disappointments due to inadequate mathematical preparation.[21]

These pamphlets and articles bear witness to an increasingly recognized need for better cooperation between the high schools and colleges. Steps that have been taken in this direction include a symposium on "The Undergraduate Mathematical Curriculum" in 1944 which also included a discussion of "The Changing Curriculum in Secondary Schools" and a second symposium on college entrance requirements in 1948. Both symposia were sponsored by the Mathematical Association of America. At the latter C. N. Shuster seconded as do many others an earlier suggestion of F. L. Wrenn's that a new, extensive, well-financed study of our entire mathematics program is at present a sore need.[22]

One further guidance pamphlet that should be cited is *The Outlook for Women in Mathematics and Statistics* published as Bulletin No. 223–4 of the Women's Bureau of the United States Department of Labor. That both guidance problems and the increasing importance of statistics are international in character is witnessed by the fact that the first of several articles on "Careers in Mathematics" in the English *Mathematical Gazette* was titled "Careers for Girls"[23] and emphasized their role in statistical computation.

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[20] Cleon C. Richtmeyer, Chairman, *A Mathematics Student—To Be or Not to Be.*

[21] For discussions of some of the problems of college students with mathematics deficiencies see Benz, Harry E., "Students Entering College Mathematics without Credit in High School Mathematics," *School Review*, 54, pp. 334–346, June 1946.

[22] Shuster, C. N., "A Call for Reform in High School Mathematics," *The American Mathematical Monthly*, 55, pp. 472–475, October 1948.

[23] Comrie, L. J., "Careers for Girls," *The Mathematical Gazette*, 28, pp. 90 ff., July, 1944.

Mathematical News Items

Any attempt to outline progress in mathematics itself is both futile and out of place here. However, some trends are both interesting and of some significance for secondary school teaching and guidance. For instance it is of interest to note that in the past few years the following new journals have been founded in this country: *Tables and Aids to Computation*, *Communications in Applied Mathematics*, *Quarterly of Applied Mathematics*, *Applied Mechanics Review*. The trend toward applied mathematics displayed by these titles is further emphasized by noting that the American Mathematics Society has recently begun to sponsor regularly a Symposium in Applied Mathematics. Government research grants are being made to support research in pure mathematics as well as in applications. In this connection it is interesting to note that of the Atomic Energy Commission scholarships granted at the University of Michigan two were in physics, one in chemistry, and three in mathematics.

It should also be noted that the *Mathematics Magazine* has succeeded the *National Mathematics Magazine*, that there is a new *Canadian Journal of Mathematics* and that there is a new journal of the history of science, *Archives*, partially financed by UNESCO. These and other facts show that activity in pure mathematics and in the history and philosophy of science continue in addition to the upsurge in applied mathematics and statistics. Three new foreign exposition-pedagogical-historical journals, *Elemente der Mathematik*, *Simon Stevin*, *The Australian Mathematics Teacher*, confirm this.

Mathematical Education Abroad

The new educational program in England formulated in the act of 1944 is having its repercussions upon mathematics education there which in turn are being felt in Australia. *The Australian Mathematics Teacher* quotes English and Scotch committee reports but also refers approvingly to American texts and programs. American readers will be interested to note some of the themes and plans stressed in these reports. For instance one article[24] refers to a "multi-lane" program, insists that schools must be "child centered," that research on teaching methods is much needed, that problems must be within the experience of the children, and that "practical or figureless" problems where children collect their own data should be used more. *The Cambridge Alternative (Experimental) Syllabus of Geometry and Trigonometry*[25] carries such suggestions as fewer required theorems, less memory work, more trigonometry fused with geometry, more

[24] "The Place of Mathematics in Secondary (Modern) Schools," *The Mathematical Gazette*, 30, pp. 250 ff. December 1946.

[25] *The Mathematical Gazette*, 27, p. 83 ff., May 1943; 27, p. 105 ff., 158 ff., July 1943; 28, p. 125 ff., October 1944.

three dimensional work including problems requiring trigonometry and the drawing of plans and elevations, an emphasis upon such practical topics as scale drawing, maps, and navigation.

A recent Scotch committee report calls for emphasis on understanding, reduction of the emphasis on formal geometry and algebraic manipulation, more time on mensuration, drawing, and solid geometry, collection of equipment and a library. The use of visual aids is much discussed in England and Australia too.

Questions and Conclusions

As we asked questions some persons fired them back. Here are a few significant and popular ones. Is there material not merely repeating earlier work and inherently interesting in its nature and organization which will improve the effectiveness of general mathematics in the ninth year? Are there being tried out any significant changes in the approach to first year algebra? How can we improve geometry instruction to make it more functional and interesting? Should there be a "second track" in geometry? These questions point up several needs noted earlier. A first need is for an improved exchange of information about mathematics education. William Storer of Albia, Iowa, is compiling a bibliography of published and unpublished mathematics education research in Iowa, but we need more of this sort of service work. Further there is a need for a complete study of the mathematics curriculum, for improved high school and college cooperation, and for focusing some attention upon college general mathematics.

AN ORDINARY DUMB-BELL OR POOR TEACHING?

Contributed by James B. Davis
Lower Merion Senior High School, Ardmore, Pa.

A little girl offered the following composition on anatomy:
"Anatomy is the human body. It is divided in three separate parts, the haid, the chest, and the stummick. The haid holds the skull and the brains, if there is any; the chest holds the liver and the stummick holds the bowels, which are a, e, i, o, and u, and sometimes w and y." (Source Unknown)

KODAK OPENS NEW LABORATORY IN PANAMA

Opening of a new research laboratory in Panama City, Panama, was an nounced today by Eastman Kodak Company.

It is designed for the study of photographic materials under tropical conditions. Its facilities include a modern 2-story building in the Juan Franco area of Panama City and a jungle test station on Barro Colorado Island in Gatun Lake, part of the Panama Canal.

The main building has about 10,000 square feet of space.

ADJUNCTS TO SCIENCE INSTRUCTION*

KENNETH E. ANDERSON
The University of Kansas, Lawrence, Kansas

As was indicated in a previous article, the biology and chemistry teachers in the fifty-six representative high schools in Minnesota, submitted a schedule describing their instructional practices and procedures. One section of the schedule was devoted to the adjuncts of science instruction such as the field trip, the science club, library books, periodicals, and visual aids.

The following statements regarding the first four adjuncts mentioned in the previous paragraph, were obtained by an analysis of the schedule:

1. The percentage of teachers sponsoring a science club was 12 per cent.
2. The percentage of teachers who took their students on planned field trips was 55 per cent.
3. The percentage of teachers indicating a "good supply," "fair supply," and "poor supply" of science books in the school library was 26 per cent, 44 per cent, and 30 per cent respectively.
4. The median number of magazines of a scientific nature taken by the school or teacher and available to students was 1.64.
5. The following magazines were the most frequently mentioned out of the thirty-two indicated as taken by the school or teacher and available to students: *Popular Science*, *Science News Letter*, *Science Digest*, *Science Illustrated*, *Nature Magazine*, *Popular Mechanics*, and *Chemistry Leaflet*.

The study of visual aids was restricted to the following:

A. Standard slide projector ($3\frac{1}{4}\times4$)
B. Miniature slide projector (2×2)
C. Film strip projector
D. Opaque projector
E. Micro-film projector (to project a page of a book from 35 mm film)
F. Silent movie projector
G. Sound movie projector
H. Combination projector

The possession or use of the visual aids indicated above and the

* This article is but a small part of the study: "The Relative Achievements of the Objectives of Secondary School Science in a Representative Sampling of Fifty-Six Minnesota High Schools," unpublished Doctoral Dissertation, University of Minnesota, 1949. Copies of the complete summary may be had on request, by writing the author at the University of Kansas.

median times used per year is indicated by the following table:

VISUAL AIDS USED BY SCIENCE TEACHERS

Type of Aid	A	B	C	D	E	F	G	H
Possession or Use by Chemistry Teachers*	9	3	11	2	0	3	31	5
Median Times Used Per Year	9	10	5	5	0	3	6	15
Possession or Use by Biology Teachers*	16	6	21	5	4	5	35	9
Median Times Used Per Year	5	6	6	5	4	5	10	10

* There were 55 chemistry teachers and 58 biology teachers in the study. Thus 9 chemistry teachers had type A available for use and used it a median number of 9 times per year.

This brief description of the adjuncts to science instruction indicates that in the year 1946–47, the teachers in this particular study were not making full use of the aids described. The description indicates that the use of library books and periodicals on science needs to be increased. Although chemistry teachers as a group had less visual aid equipment at hand, they apparently were making greater use of the aids than were the biology teachers. Much more could be done in this area of science instruction if more funds were made available to buy visual aids, books, and periodicals. The dearth of activity as regards the science club and the field trip could be corrected by equipping future teachers and those now in service with the skills required to conduct a good science club and field trip. Students in our science classes will be more stimulated if the usual mode of instruction is enriched and supplemented by proven adjuncts to science instruction.

THE QUIZ SECTION

JULIUS SUMNER MILLER

Michigan College of Mining & Technology, Sault Ste. Marie, Michigan

1. A man walking with speed v wishes to cross a railroad track as far as possible ahead of a train approaching at speed V. How should he cross?

2. A gun has a range R on the horizontal. It is required to put a shot over a ridge H ft. high. Find the limiting horizontal distance of the ridge.

3. A shot fired at an angle A is observed to strike the foot of the ridge. If B is the angle subtended by the ridge at the gun find the elevation required to just strike the top of the ridge.

4. A particle projected with a given velocity from a point P can pass through another point P' by two possible paths. Find how the times of flight for these two paths are related.

5. Find the least separation of two cars traveling along the level road at v ft./sec. in order that mud from the tires of the forward car *just miss* the windshield of the car behind.

TEACHER RESEARCH IN DAILY CLASSES

Committee on Teacher Research in Daily Classes
J. R. MAYOR, *Chairman*

As one of the Policy Projects Committees of the Central Association of Science and Mathematics Teachers, the Committee on Teacher Research in Daily Classes is attempting to encourage teacher research in daily classes and to promote publication and sharing of this research.

Teachers are urged to send to SCHOOL SCIENCE AND MATHEMATICS, or to the Committee, descriptions of any materials that they believe would help other teachers do a more effective job. A report of new methods and new topics, found valuable through experience and experimentation, can stimulate experienced and inexperienced teachers alike.

In addition to urging teachers to share with others their favorite teaching techniques the Committee is making a special study of current teaching practices in science classes and a second study on opportunities for and examples of correlation of work between science and mathematics classes.

Another project of the Committee has been to ask teachers to volunteer to work on a problem of special interest to them this year. The response has indicated that some good reports can be expected at the end of this school year. Among those teachers who are carrying on these special studies this year are: Burton F. Alexander, Petersburg, Virginia; John A. Brown, Merrill, Wisconsin; Sadie Clapper, Springfield, Illinois; Sister M. Constantia, Toledo, Ohio; Dorothy Cox, Carterville, Illinois; Elbert Fulkerson, Southern Illinois University, Carbondale, Illinois; Lucy Glascock, Dupo, Illinois; R. Maurine Johnson, Casey, Illinois; Mary A. Peters, Elgin, Illinois; Marguerite Wolfinger, Superior, Wisconsin.

The members of the Committee are Margaret Joseph, Shorewood High School, Milwaukee; Ben A. Peacock, Wauwatosa High School, Wauwatosa, Wisconsin; Milton Pella, Wisconsin High School, Madison; Frederick W. Schuler, West High School, Madison; J. R. Mayor, University of Wisconsin, Chairman.

The following reports among the first received are illustrative of short reports of new ideas or teaching techniques. All good teachers have materials of this kind which should be shared with others.

SOME TEACHING AIDS IN GEOMETRY

For many construction problems in plane geometry, I ask students to work with a partner. If the problem is to construct a right triangle having given the

hypotenuse and an acute angle, we discuss whether or not two right triangles having the hypotenuse and an acute angle of one equal to the hypotenuse and an acute angle of another will be congruent. Then each student chooses a partner. After two or three constructions working with the same student I ask them to choose a different partner. I have found that it works better if they choose their own partners than if I do it. One of the partners draws on his paper a line segment which he is going to use for the hypotenuse and an acute angle which he will use for the acute angle. The other partner copies the line segment and acute angle on his paper. Each student makes the construction independently and they are anxious to see if the triangle are congruent. To determine if the triangles are congruent, the students place one paper on top of the other, hold the paper up to the light and try to make the triangles coincide. Sometimes it is necessary, of course, to turn one paper around or turn it over. If the triangles are not congruent, the two usually go into a huddle to try to determine where the mistake is. This procedure adds interest, is a good checking device, results in more accurate constructions, makes for better attitudes and brings better cooperation from the entire class.

A child's peg board can be used to show different kinds of triangles and the medians and altitudes of those triangles. All that is necessary is to place pegs at the vertices of the desired triangles, run elastic thread on the outside of the pegs for the sides of the triangles, and run other elastic threads from peg to peg to describe medians and altitudes. The pegs can be moved from place to place (from hole to hole) to form different triangles and the change in the median can be easily seen.

Contributed by R. Maurine Johnson, Case Community Unit Schools, Casey, Illinois.

AN EXTENSION OF HORNER'S SYNTHETIC DIVISION TO DIVISORS OF DEGREE HIGHER THAN ONE

To divide a polynomial in x by a divisor in the form $x-a$, W. G. Horner's method of synthetic division is often used. Its development may be traced by observing the division of $2x^3+x^2-14x+6$ by $x-2$. By the long method,

$$
\begin{array}{r}
2x^2+\ 5x-4 \\
\hline
x-2\,\big)\,2x^3+\ x^2-14x+6 \\
\underline{2x^3-4x^2} \\
5x^2-14x \\
\underline{5x^2-10x} \\
-\ 4x+6 \\
\underline{-\ 4x+8} \\
-2
\end{array}
$$

Let us consider only the detached coefficients:

$$
\begin{array}{rrrrr}
 & & \textcircled{2} & \textcircled{5} & \textcircled{-4} \\
1 & -2\,\big) & \textcircled{2} & 1 & -14 \qquad 6 \\
 & & \textcircled{2} & -4 & \\
 & & & \boxed{5} & -14 \\
 & & & \textcircled{5} & -10 \\
 & & & & \boxed{-4} \qquad 6 \\
 & & & & \textcircled{-4} \qquad 8 \\
 & & & & \hline
 & & & & -2
\end{array}
$$

Notice the correspondences among the coefficients and that the coefficient

of the x term in the divisor is not essential to the division (as long as it equals one). We may then delete the circled coefficients and the 1.

The form may be condensed in the following manner:

$$\begin{array}{rrrrrr} 2 & 1 & -14 & 6 &) & \underline{-2} \\ & -4 & -10 & 8 & & \\ \hline 2 & 5 & -4 & / \ -2 & & \end{array}$$

By changing the sign of the divisor we may replace subtraction by addition.

It would be natural to inquire whether this method could be adapted for higher divisors. The following work will show the evolution of just such an adaptation.

Dividing $3x^4+16x^3+14x^2-11x+5$ by x^2+3x-2 with detached coefficients, we will have

$$\begin{array}{rrrrrrr} & & & & 3 & 7 & -1 \\ 1 & 3 & -2\sqrt{3} & 16 & 14 & -11 & 5 \\ & & 3 & 9 & -6 & & \\ \hline & & & 7 & 20 & -11 & \\ & & & 7 & 21 & -14 & \\ \hline & & & & -1 & 3 & 5 \\ & & & & -1 & -3 & 2 \\ \hline & & & & & 6 & 3 \end{array}$$

Making deletions similar to the previous problems, we have

$$\begin{array}{rrrrrr} 3 & -2\sqrt{3} & 16 & 14 & -11 & 5 \\ & & 9 & -6 & & \\ \hline & & 7 & 20 & -11 & \\ & & & 21 & -14 & \\ \hline & & & -1 & 3 & 5 \\ & & & & -3 & 2 \\ \hline & & & & 6 & 3 \end{array}$$

Once more we may condense the form,

$$\begin{array}{rrrrrrrr} 3 & 16 & 14 & -11 & 5 &) & \underline{3} & \underline{-2} \\ & & -6 & -14 & 2 & & & \\ \hline & 16 & 20 & 3 & & & & \\ & 9 & 21 & -3 & & & & \\ \hline 3 & 7 & -1 & / \ 6 & 3 & & & \end{array}$$

Upon changing the sign of the divisor, we may add.

It must be remembered that this system works only when the coefficient of the highest power of x in the divisor is equal to 1.

To clarify the process, we may note the form when starting

$$\begin{array}{rrrrrrrr} 3 & 16 & 14 & -11 & 5 &) & \underline{-3} & \underline{2} \\ \hline & 16 & & & & & & \\ \hline 3 & & & / & & & & \end{array}$$

There are as many horizontal lines as figures in the synthetic "divisor." The first coefficients are brought down in a step-wise fashion. As many places are left for the remainder as there are lines.

Then the divisor is multiplied by the figure under the last line and the results

are put down in the following manner:

3	16	14	−11	5	)	−3	2
		6					
	16	20					
	−9						
3	7	/					

Next the 7 is multiplied by the divisor and the results are similarly placed. The process is continued until all the places are filled out.

Contributed by Robert Blattner, Student, Shorewood High School, Milwaukee.

THE CRUISER'S STICK

The school forest owned by our high school lends itself to some fine correlation with various subjects. One of our most successful units in mathematics was a study of the use and mathematical background of the cruiser's stick by our advanced algebra and trigonometry class.

The cruiser's stick is used by the woodsman and forester to make approximate measurements of the height of trees, diameter of trees, and inaccessible distances. A study of the history of the stick by the class indicates that the stick is probably an application of Jacob's Staff, an ancient instrument used in navigation and indirect measurement. It is necessary for each student to make his own stick. It is approximately one half inch square and as long as the individual's reach from the eye to the center of the palm of his hand when extended horizontally. The principle involved is that of similar triangles resulting from a vertical object held at a constant distance (arm length) from the eye.

For measuring the height of objects the instrument is calibrated by an application of similar triangles.

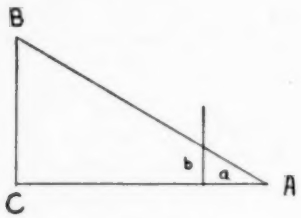

FIG. 1

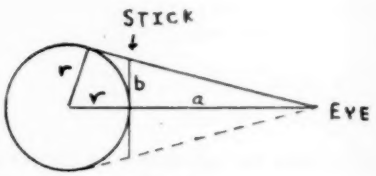

FIG. 2

$$\frac{BC}{b}=\frac{AC}{a}$$

$$b=\frac{aBC}{AC}$$ see Figure 1.

b = the unit calibration of stick
BC = the unit used in measuring, such as 100 inches
a = normal arm reach of individual
AC = distance from eye to object, a constant

Example: At a distance of one chain (66 feet) from the object, an arm reach of 25 inches, and a unit measurement of 100 inches (one pulpwood log), one unit mark on the rod would be approximately 3.16 inches.

A second calibration on the rod is used for measuring diameter of trees. We calibrated using an application of similar triangles and the Theorem of Pythagoras. The formula developed was

$$b=\sqrt{\frac{ar^2}{2r+a}}.$$

In trigonometry using sin A, cos A, and tan A we proved the same formula.
Example: see Figure 2

a = arm reach = 25″
r = radius = 10″
b = ½ calibration $\sqrt{\frac{2500}{45}}$

$b = 7.45$
$2b$ = calibration on rod = 14.9″

The class worked out its table of calibration for diameters from 4 inches to 30 inches.

The unit includes appreciation and knowledge of functions, similar triangles, the Theorem of Pythagoras, and trigonometry. A local forester was brought in to explain the use of the stick in the woods and he, also, discussed with the class the uses of mathematics in forestry and conservation. Probably because of its practical application to an intriguing subject interest ran high and a field trip to the forest resulted.

Contributed by John A. Brown, Merrill, Wisconsin.

THE CIRCLE FORMULA

In presenting the relationship between the formula for the area of a circle and that for the area of a parallelogram, the industrial arts department aided materially when two of the general mathematics class boys undertook the construction of the following visual aid device.

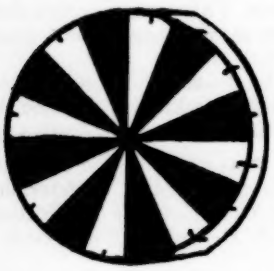

FIG. 1

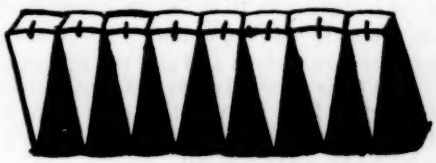

FIG. 2

Fig. 1 is constructed of a wooden circle, one foot in diameter, which is cut into sixteen sectors and held together with a metal band and locking bolt in the center. The alternating light and dark finishes of the sectors readily illustrate the concept that

$\frac{1}{2}C$ corresponds to b

when the sectors are rearranged into the shape of the parallelogram of Fig. 2, in which the height is seen to correspond to the radius of the original circle.

From that point on, the development of the circle area formula unfolds quite graphically from the familiar

$$A=bh$$

If

$$b=\tfrac{1}{2}C=\tfrac{1}{2}\cdot 2\pi r=\pi r$$
$$h=r$$

Then, by substituting into the formula

$$A=\pi r\cdot r$$

or

$$A=\pi r^2,$$

the area of the circle.

And then, as final confirmation of the relationship of the two formulas, each is individually solved by substituting the dimensions of the two geometric figures, thus:

	Parallelogram	*Circle*
	$A=bh$	$A=\pi r^2$
If	$b=1.57$ ft. approximately (Measured length)	$\pi=3.14$
	$h=\frac{1}{2}$ ft.	$r=\frac{1}{2}$ ft.
Then	$A=1.57\times\frac{1}{2}=.785$	$A=3.14\times\frac{1}{2}\times\frac{1}{2}=.785$
$\therefore$	$A=.785$ sq. ft.	$\therefore$ $A=.785$ sq. ft.

Contributed by Marguerite E. Wolfinger, East High School, Superior, Wis.

A METHOD OF WRITING AN EQUATION WHEN ITS 4 ROOTS ARE KNOWN

If one wishes to form the equation when its 4 roots are known, either of two methods are usually applied. Linear factors, one corresponding to each root, are multiplied together to give the desired equation or else the coefficients in the equation are determined by finding the sum of the products of the roots taken one, two, three, and four at a time. If the roots are taken an odd number at a time, the sign is changed; otherwise the same sign is used. This method is complicated so I found that a general formula of two quadratics multiplied together will enable one to obtain the equation in just two steps. This same principle may be applied if there are more or less roots by working out a similar general equation.

Since $(x^2+ax+b)\ (x^2+cx+d)=x^4+(a+c)x^3+(b+d+ac)x^2+(bc+ad)x+bd$, one may apply this to write the equation whose roots are known. Assume the roots are 6, 1, $-1+\sqrt{6}$, and $-1-\sqrt{6}$. One can write the equation mentally if the roots are 6 and 1 and also the equation whose roots are $-1\pm\sqrt{6}$ to obtain (x^2-7x+6) and (x^2+2x-5). The general formula is now applied to determine the quartic. It is mental but each step is shown to explain its application. $x^4+(-7+2)x^3+(6-5-14)x^2+(12+35)x+(-30)=0$. Hence the final result is $x^4-5x^3-13x^2+47x-30=0$.

If roots include fractions, proceed in the same way and then multiply through by the common denominator. This same general formula simplifies the multiplication of any two quadratics.

Contributed by Joseph Ehrman, Jr., Student at Shorewood High School, Milwaukee.

(Other teachers may wish to follow the example of Miss Joseph in having students submit descriptions of new processes or relationships that they have developed in connection with regular class work. The practice of encouraging students to make proposals original to them is certainly a highly commendable teaching technique.)

A SIMPLE METHOD OF FINDING TRIGONOMETRIC FUNCTIONS OF ANY ANGLE

When finding functions of obtuse or reflex angles, one usually subtracts 90°, 180°, 270°, or 360° from the given angle to obtain an angle less than 90° or else the given angle is subtracted from 180°, 270°, or 360°. To illustrate:

1. $\sin 153°17'31''=\sin(180°-153°17'31'')=\sin 26°42'29''$ or
2. $\sin 153°17'31''=\sin(90°+63°17'31'')=\cos 63°17'31''$.

3. $\cos 153°17'31'' = \cos (180° - 26°42'29'') = -\cos 26°42'29$ or
4. $\cos 153°17'31'' = \cos (90° + 63°17'31'') = -\sin 63°17'31''$.
5. $\tan 243°17'31'' = \tan (180° + 63°17'31'') = \tan 63°17'31''$ or
6. $\tan 243°17'31'' = \tan (270° - 26°42'29'') = \cot 26°42'29''$.
7. $\tan 333°17'31'' = \tan (360° - 26°42'29'') = -\tan 26°42'29''$ or
8. $\tan 333°17'31'' = \tan (270° + 63°17'31'') = -\cot 63°17'31''$.

The average pupil can mentally subtract 180°, 270°, or 360° from a given angle but invariably must write out the work to subtract from these same angles. There is a very simple method that may be applied to determine the angle by inspection. This was mentioned to a class by Professor Sophia McDonald of the University of California at Berkeley. This method leaves unchanged the number of degrees in the units place as well as the number of minutes and seconds in the angle, thus avoiding all changes in the given angle with the exception of the tens digit which is the sum of the tens and hundreds digit of the original angle. The sign of the function is obtained in the usual way. If the terminal side of the angle lies in an odd numbered quadrant, the same named function is used while the cofunction is used if the terminal side lies in an even numbered quadrant. So if one wishes to find the tan 172°15'38", merely add 1 to 7 to get the hundreds digit (8) while the minutes and seconds are the same. Then recall that an angle of 172° lies in the second quadrant so the cofunction is used. The tangent is negative in this quadrant so we know that $\tan 172°15'38'' = -\cot 82°15'38''$. Looking back at the 8 exercises at the beginning of this article, one can see at a glance that Exs. 2, 4, 5, and 8 may be done mentally using this method.

This system is possible because it selects the angle that is left over after the multiples of 90° have been subtracted from it and when one subtracts 180°, 270°, or 360° from an angle, naturally one is subtracting multiples of 90°. This can be explained algebraically. Consider a two digit number with the units and tens digits expressed by u and t respectively. The number, $10t+u$, diminished by the sum of the digits, $u+t$, $=9t$. If the sum of the digits, 6, be subtracted from the number 51, the remainder is 45. This checks with the formula for the difference since $9t = 9 \cdot 5$ or 45. It is easy to see that when one adds the digits, one subtracts the highest multiple of 9 from it. If the number is a multiple of 9, then the sum of the digits is just 9.

A three digit number is expressed as $100h+10t+u$. If a new number is obtained by adding the hundred and the tens digits for the new tens digit, then this number is expressed as $10(h+t)+u$ or $10h+10t+u$. The difference between these two numbers is $90h$. This proves the statement previously made that multiples of 90 are subtracted when one adds the hundreds digit and the tens digit for the new tens digit while the units digit remains unchanged. If the given angle is in the nineties, the one hundred eighties, etc., just use the units digit for the number of degrees in the angle. Thus, $\sin 96°12'57'' = \cos 6°12'57''$ while $\sin 186°12'57'' = -\sin 6°12'57''$. If the original angle is so large that the first application of this method results in a three digit number, just repeat the process a second time. $\cos 634°18' = \cos 94°18' = \sin 4°18'$. With very little practice every pupil can determine the function of any obtuse or reflex angle mentally.

Contributed by Margaret Joseph, Shorewood High School, Milwaukee, Wisconsin.

INSTITUTE FOR TEACHERS OF MATHEMATICS

The Association of Teachers of Mathematics in New England are sponsoring an Institute for Mathematics Teachers to be held on Wellesley College Campus, August 23–30, 1949. Among the noted speakers are Dr. Shields Warren, Professor of Pathology, Harvard Medical School, Prof. Vincent J. Glennon of Syracuse University, Prof. W. W. Rankin of Duke, Mary A. Potter of Racine, Wisconsin, Edwin H. Land, President of the Polaroid Corporation of America, Prof. Julian L. Coolidge of Harvard and many others. For further information write to Henry W. Sayer, 84 Exeter Street, Boston 16, Mass.

DIVISION BY ZERO

A. R. JERBERT
University of Washington, Seattle, Washington

Some textbooks omit this topic entirely. Others merely state flatly that division by zero is excluded from algebra. The following is a typical statement. "To divide a by b $(b\neq 0)$ is to find c so that $bc=a$. The condition $b\neq 0$, means that the divisor is not zero."

In some texts an equally dogmatic statement on the inadmissibility of zero as a divisor, is confirmed by citing a proof such as,

$$\begin{aligned} a&=b,\\ a^2&=ab,\\ a^2-b^2&=ab-b^2,\\ (a+b)(a-b)&=b(a-b),\\ a+b&=b,\\ 2b&=b,\\ 2&=1, \end{aligned} \tag{1}$$

with the suggestion that we look to this principle, or rather its non-observance, for an explanation of the fallacy. Although students are frequently able to point to the division by $a-b=0$, as the source of difficulty, further questioning is likely to reveal little, or no, real understanding. Their stock explanation, "if you divide by zero, you get infinity," suggests that they have heard something which is more intriguing than intelligible.

To divide a by b is to find x such that,

$$a=xb. \tag{2}$$

If b is zero, we have,

$$a=x\cdot 0. \tag{3}$$

Since, however,

$$x\cdot 0=0, \qquad x \text{ any number}, \tag{4}$$

equation (3) is satisfied by,

$$\begin{aligned} &\text{no value of } x, \quad \text{for} \quad a\neq 0,\\ &\text{any value of } x, \quad \text{for} \quad a=0. \end{aligned}$$

Stating these results in division form, we have,

$$a/0=\text{no value}, \qquad 0/0=\text{any value}. \tag{5}$$

Division by zero is thus either impossible, or ambiguous, and is therefore excluded from algebraic operations.

Along with division by zero it is customary to consider the division of zero by a number which is different from zero. In equation (2) we have $a=0$, $b\neq 0$, so that this equation becomes,

$$0=xb.$$

By equation (4) this is satisfied by $x=0$. To equations (5) we can add, therefore,

(6) $$0/b=0.$$

Since equations (5) and (6) furnish solutions for,

$$a/0=x, \qquad 0/0=x, \qquad 0/b=x,$$

it is natural to consider the complementary set,

$$x/b=0, \qquad x/0=0, \qquad x/0=b.$$

By the definition of division these equations signify that x is equal to,

$$b\cdot 0, \qquad 0\cdot 0, \qquad 0\cdot b,$$

respectively, so that by equation (4), $x=0$, in each instance.

Equation (5), states that $a/0=x$, is satisfied by no value of x. On the other hand, there is the remark, cited in the beginning, "if you divide by zero, you get infinity." This apparently contradictory result may be explained to advantage in connection with plotting the rectangular hyperbola, $xy=a$. If we select for x the values, 1, 1/2, 1/3, $\cdots$, the corresponding values of y are, a, $2a$, $3a$, $\cdots$, and it is clear that as,

(7) x approaches zero, y increases indefinitely.

x	y
1/1	a
1/2	$2a$
1/3	$3a$
↓	↓
0	

Thus, in the x-column the arrow points to zero as the limiting value. In the y-column the arrow simply points to larger and larger values.

It would evidently make for symmetry to have this arrow point to a symbol which matches the zero of the x-column. Adopting, therefore, the symbol ∞ (infinity) and agreeing that,

$\rightarrow\infty$ (approaches infinity) = increases indefinitely,

we have in place of (7),

$$x\rightarrow 0, \qquad y\rightarrow\infty,$$

or, since $y=a/x$,

$$x\rightarrow 0, \qquad a/x\rightarrow\infty. \tag{8}$$

For the sake of still greater brevity in statement we may choose to abandon the language of approach indicated by the arrows in (8), and simply say, flatly,

$$x=0, \qquad a/x=\infty,$$

or more simply still,

$$a/0=\infty. \tag{9}$$

Although this seems to contradict equation (5), the point is that equation (9) is a symbolic equality which is equivalent to (8). In other words the $a/0$ in equation (9) is a/x with the understanding that $x\rightarrow 0$. Moreover, ∞ is not a number in the ordinary sense, but simply a concise way of indicating the indefinitely large values assumed by a/x as $x\rightarrow 0$. The fact that equation (9) has the same meaning as (8) could be made explicit by placing arrows before 0 and ∞ as in the equation,

$$a/\rightarrow 0=\rightarrow\infty.$$

However, the awkwardness of inserting arrows, makes it preferable to retain equation (9) and simply have the arrows understood.

In a similar manner we can establish the equality,

$$a/\infty=0, \tag{10}$$

which means that if a is divided by a variable divisor which increases indefinitely, the quotient approaches zero as a limit.

If it is objected that we are forcing upon equations (9) and (10) more meaning than meets the eye, it should be pointed out, and this cannot be done too often, that the symbols of mathematics are man-made. We are, therefore, their masters, and like Humpty Dumpty in Alice in Wonderland, we can make them mean whatever we choose to have them mean.[1]

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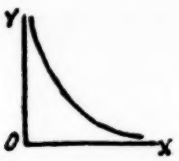
[1] Some writers feel that equations (9) and (10) should be eliminated entirely because of the possibility of misinterpretation. To be consistent with this point of view, however, we should replace,

$$\tan \pi/2=\infty,$$

for example, by,

$$\lim_{x\rightarrow\pi/2} \tan x=\infty.$$



In the figure we have indicated the first quadrant branch of the hyperbola, $xy=a$, $a>0$. The facts expressed by equations (9) and (10) can be seen intuitively in the approach of the curve to the $+y$, and the $+x$, axes, respectively. In plotting,

$$y=(x^2-3)/(x-2)(x-1),$$

for example, we can say as in equation (5), that for $x=1$, and $x=2$, y has no value. It is, however, more instructive to think in terms of equation (9) and note that as x approaches 1, or 2, y increases indefinitely.

On the theory that one might as well hang for a sheep as a lamb, we observe that since we are committing a fallacy in either case, we could have, with equal justice, in place of equation $(1)_5$ the equality,

$$x=y,$$

where x and y are any two numbers. The members of equation $(1)_4$ are both zero, and since we are dividing by zero, equation $(1)_5$ takes the form,

$$0/0=0/0.$$

By equation $(5)_2$ we can substitute any number x, and an equally general y for the left and right members, respectively. The equation $a+b=b$, is merely a particular instance of $x=y$, which results from the cancelling procedure.

Moreover, since ∞ is not a number in the ordinary sense, we should go a step further, and write,

$$\tan x \text{ increases indefinitely, as } x\to\pi/2.$$

In like manner we should refrain from writing,

$$\int_1^{\infty} dx/1+x^2=\pi/4,$$

and in its place, put,

$$\lim_{x\to\infty}\int_1^{x} dx/1+x^2=\pi/4,$$

or "better" still,

$$\int_1^{X} dx/1+x^2\to\pi/4, \text{ as } X \text{ increases indefinitely.}$$

Although the danger of misinterpretation is a very real one, the remedy, in the writer's opinion, is careful explanation and not the abandonment of a usefully concise notation.

The fallacy in equations (1) can be exhibited in the baldest possible form, by citing an equality such as,

$$10 \cdot 0 = 5 \cdot 0,^{2}$$

and cancelling the zeros to obtain,

$$10 = 5.$$

In the streamlined version it should be clear that the fallacy turns on the fact that zero is a non-discriminating multiplier. Hence the fact that $a \cdot 0 = b \cdot 0$, gives no indication of the relative values of a and b.

Feeling that a partial, or evasive, explanation is worse than none, the writer has had in mind, in this extended treatment, the viewpoint of the teacher who, when asked what he would do if called upon for the explanation of a rather difficult topic, replied that he would "tell them." Certainly, a categorical statement, unsupported by adequate explanation, that division by zero is not permissible, can only serve to confuse the student. The result is that, to such mysteries as $- \times - = +$, to subtract you add, but to add you subtract, he complacently adds the twin mysteries, if you divide by zero, you get no value, or infinity, that is to say, everything or nothing.

---

[2] "Motivation" for this equation could be had by writing,

$$5 \cdot 2 \cdot 0 = 5 \cdot 2 \cdot 0,$$

and applying the associative law to obtain,

$$(5 \cdot 2) \cdot 0 = 5 \cdot (2 \cdot 0).$$

SUPPLEMENTARY COURSES IN CHEMISTRY

A new experimental program of supplementary courses in chemistry has been initiated in the Department of Chemistry of Roosevelt College in Chicago. The program offers students an opportunity for independent study of one assigned organic and inorganic compound for three years.

Described as an "effort to break away from straight-jacket systems of education where all students do exactly the same thing," it is designed to teach students the techniques of individual study and provide training for future independent research.

Chemistry majors are eligible to enter the program after completing the freshman chemistry courses. They are assigned an individual compound which they may study for the remaining three years of their undergraduate work in conjunction with progressively advanced courses offered by the Department. The subject matter and experiments performed with their individually studied compounds are related to their general chemistry programs.

Photographic floodlight, producing light from seven to 15 times the intensity of sunlight on a bright day, is particularly for use in taking motion pictures at speeds up to 8,000 individual frames a second for study in slow motion. Such photography is widely used in research.

CHALLENGING TEACHERS

A. C. NELSON
The Manlius School, Manlius, New York

Teachers are human beings. Human beings are usually stimulated by a challenge. We capitalize on this characteristic by apprizing teachers before they meet their classes what should be expected from each of their pupils.

In order to make this prognosis, objective evidence is obtained from a series of Standardized Tests which are taken by the entering student during the "orientation period" which precedes the formal opening of school. In addition to an Intelligence Test and the American Council Psychological Examination, tests are given in reading and also in all preceding subjects including mathematics and science.

After many hours of work by the entire faculty, the results are presented to the Principal and the Director of Scheduling. Careful deliberation then determines not only the actual subjects to be studied, but also at what level of difficulty the student is to be placed. This, of course, implies homogeneous grouping. These groups are indicated by X, Y, and Z sections. The X sections contain those who are best equipped and best prepared to attempt the highest standards. The Y sections constitute the majority with average preparation and ability, while the Z sections are made up of those for whom secondary schooling should most likely terminate their formal education.

In the fall, each teacher is given the objective evidence and an idea of the approximate results expected. Near the end of the school year, each teacher knows the actual results will be studied by the principal.

Some pupils will need more individual attention than others. Many of these are actually assigned to the instructor for an extra period daily. During these Tutorial Periods, the instructor tries to fill in deficiencies in previous preparation for his subject. In mathematics, it usually means work on the fundamentals of arithmetic or algebra. In the sciences, it usually requires personalized assistance in teaching the student how to go about studying a scientific subject. In addition to this assistance by the mathematics and science teachers, a remedial reading program is provided to improve reading comprehension and speed.

For the X sections, supplemental topics are included and a conference period is provided each afternoon after regular classes when all members of the faculty are available to help students with their problems. This help is available to all students, not only to the more advanced pupils.

Since provisions are made to work individually with students every

day, the teacher has ample opportunity to reach the goal set up for him. For example, let us say that John Jones is enrolled in trigonometry. His I.Q. is 120, his quantitative percentile on the American Council Test was 82, and, in his previous mathematics course, intermediate algebra, he achieved the 76th percentile. On the basis of this evidence, it seems safe to assume that, if an effective job of teaching is done, at the end of the course in trigonometry, John Jones should approximate the 76th percentile on a standardized test in trigonometry. (All norms used are on a comparable basis.) This reasoning seems justifiable because evidence shows that this boy is above average in mental ability, in the upper quarter so far as mathematical aptitude is concerned and, furthermore, the teacher who had him the year before managed to get John Jones to score at the 76th percentile in intermediate algebra.

By extending the reasoning presented in the case of John Jones, you have a fairly defensible theory. On the other hand, it applies to those below average in ability and aptitude. One does not expect a boy with an I.Q. below average to do outstanding work. It is true that, in some instances, surprising results are obtained through strong motivation plus cooperative perseverance on the part of pupil and teacher.

As mentioned earlier, each teacher knows that near the end of the year the test results of his students will be carefully scrutinized by the principal during a conference with that teacher. This in itself provides a powerful challenge to teach effectively and there is considerable satisfaction in receiving a commendation of "Well Done" from your principal.

It is realized that effectiveness of instruction should not be judged extensively on test results but evidence seems to indicate that the superior teacher (as rated by intangible methods) obtains the better results as measured by standardized tests.

The table below presents actual cases taken from last year's school population. The I.Q. was obtained from an Otis Test. The Q Score from A.C.P.E. The "Previous Math" gives the result obtained in the preceding course. The "Expected Percentile" is our prognosticated result. The last column shows actual results obtained.

MATH:	I.Q.	Percentile Q-Score	Previous Math Percentile	Expected Percentile	Actual Percentile
1.	116	65	40	35–45	59
2.	114	70	68	63–73	86
3.	120	82	71	66–76	76
4.	116	57	38	33–43	20
5.	112	26	28	24–30	16
6.	102	28	36	28–36	15

SCIENCE:	I.Q.	Reading Percentile	Previous Science Percentile	Expected Percentile	Actual Percentile
1.	105	4	6	5– 9	29
2.	121	24	54	50–60	89
3.	110	51	49	44–54	70
4.	107	44	84	78–86	66
5.	106	20	62	58–64	18
6.	107	34	72	67–77	40

In each group above, the first three actual cases seemed to indicate superior teaching effectiveness because the actual results obtained exceeded the expected range; and the other three cases were chosen to show results below expectation.

USE OF MNEMONIC DEVICES IN MATHEMATICS

CHARLES W. MATHEWS
Washington University, St. Louis, Missouri

What color are fire engines? Let me see. Before fire engines, men went to fires on foot. A foot is twelve inches. Twelve inches is a ruler. A ruler of the British Empire was Queen Mary. The Queen Mary is a ship. Ships sail the oceans. Across the ocean is Russia. A Russian is a red. Hence, fire engines are red. Such a simple method to use for remembering that fire engines—at least some of them—are red!

In teaching mathematics mnemonic devises are used at times when it is easier to learn the facts from the fundamentals. On page 649 of the October 1947 issue of SCHOOL SCIENCE AND MATHEMATICS is a mnemonic aid for determining the sign of a trigonometric function of an angle whose terminal side falls in a particular quadrant when the angle is placed in standard position. The rule is stated like this.

"Almost every school has an R.O.T.C. During the First World War the similar organization was called the Student Army Training Corps, or the S.A.T.C. With these remarks, I write on the board

S	A
T	C

with the perpendicular lines between them to suggest the four quadrants. The letter A stands for all, and means that in that quadrant all the functions are positive. S stands for sine; it (and hence its reciprocal) are positive in the second quadrant as suggested by the position of S. T is for tangent and its reciprocal, which are positive in the third quadrant; and C is for cosine."

This is objectionable for the following reasons.

1) Only a small percentage of high schools have R.O.T.C. units and few high school students have ever heard of the Student Army Training Corps. Because of unfamiliarity they must memorize these words.

2) There is no particular reason why the letters should be put down in the fashion which they are. This must be memorized.

3) The students must remember that A is the first letter of ALL, S of SINE, etc.

4) The students must know the reciprocal relations of the trigonometric functions.

5) The students must remember that these functions are positive (not negative) in these quadrants and ones not mentioned are negative (not positive) in those quadrants.

6) Finally, the student does not obtain the answer for problems in which the angle is $90n$ degrees where $n = 0, \pm 1, \pm 2, \ldots$.

On the other hand, if the student knows the definition of the trigonometric functions of a general angle he is fully equipped to determine the sign of the trigonometric function of any angle. Nothing new or extra need be learned. Suppose, for example, it is desired to find the sign of the secant in the second quadrant. The secant of any angle is the radius vector, r, divided by the x-coordinate. r is positive. x is negative in the second quadrant. Hence the secant would be negative. The only thing that one needs to know is the fundamental definition of the trigonometric functions which is already known by this time.

In this particular problem understanding is more to be desired than speed. A few weeks later when the student becomes familiar with the graphs of the trigonometric functions he can determine immediately the signs of the functions from the knowledge of the graphs.

An effective mnemonic device must be one which is based on well known facts and should be simple. It should not admit exceptions or hamper generalization of concepts or procedures. Don't suggest mnemonic devices unless they are good ones. Encourage the students to develop their own system for remembering things that are difficult to memorize. They often can do better with a personalized memory aid than with a "mail order" variety.

Education is a polite form of mental exercise unless the student feels for himself the tang of original thinking, the bite of new ideas, and the heat of social and intellectual controversy.

—HAROLD TAYLOR

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED SIXTY-NINTH MEETING

Saturday, November 6, 1948
Worcester Polytechnic Institute, Worcester, Mass.

10:00 A.M. Greetings by the president of WPI.
Admiral Watt Tyler Cluverius

10:10 A.M. Address: Examples of Science at Work in Industry
Assistant Research Director, Dr. Lowell H. Milligan, Norton Company

11:00 A.M. Address: Space Perception
Dr. Paul Booder, Director of Bureau of Visual Science, American Optical Company

11:50 A.M. Business Meeting

12:15 A.M. Address: Physics at WPI.
Dr. Morton Masius, Head of the Physics Department

12:50 A.M. Lunch Period, Cafeteria Style, 99¢

1:30 A.M. Demonstrations in Electricity
Prof. K. Mayer, WPI. Physics Department

2:15 A.M. Apparatus Committee Report
Mr. W. Roscoe Fletcher, Chairman

Officers for the Association 1948–1949

President, Raymond F. Scott, Rindge Technical High School, Cambridge, Mass.
Vice-president, Anna E. Holman, Winsor School, Boston, Mass.
Secretary and Treasurer, Albert R. Clish, Belmont High School, Belmont, Mass.

REPORT OF THE 169TH MEETING OF THE E.A.P.T.

Saturday, November 6, 1949
Worcester Polytechnic Institute
Worcester, Mass.

The 169th meeting of the E.A.P.T. started promptly at 10:00 A.M. EAST with a few words of welcome from the president of Worcester Polytechnic Institute, Admiral Watt Tyler Cluverius. In a very few moments the Admiral reviewed the importance of physics in industry and in the late world conflict. He stressed the fact that there is more physics in the lives of all of us today than ever before and ended his greetings with "physics is on the threshold of the concern of all the people."

The Norton Company, a manufacturer of abrasives in Worcester, Massachusetts, very generously, sent us a representative, Assistant Research Director Dr. Lowell H. Milligan, who spoke on "Examples of Science at Work in Industry."

Dr. Milligan's talk concerned itself with three distinct topics: Surfaces, Hardness and Pure Oxide Refractories.

The Association was assured that though the topics seemed miles apart, the Norton Company found them very closely related. The type of surface on a given metal depends in some measure on the hardness of the finishing tool and both the tool and the metal are very definitely tied to the development of suitable refractories. "Why are we interested in surfaces?" Because the surface must meet the working conditions.

If we are to have a real interest in surfaces we must have some kind of a scale for the measurement of surfaces. Various measures have been developed and these scales or measurement systems can be classified as follows:

1. A physical method, a feeler runs on the surface and shows by means of magnifying levers the "wiggles."

2. An optical method, the interferometer method as developed by Zeiss.
3. An optical method, (a) visual examination with the naked eye; (b) visual examination with the microscope; (c) visual examination of photographs made with the electron microscope.
4. A physical-optical method, visual examination of differences in elevation by perpendicular cross sections and by taper sections as indicated on the photographs. The taper sections give automatic magnification.

Dr. Milligan illustrated his talk with slides showing the above four methods of surface measurement. He also showed models to illustrate the cross section and the taper section method of surface measurement.

With a little thought one might assume that reflectivity would be a good measure of surface conditions, but such is not the case. Consider two surfaces whose cross sections are indicated by Fig. 1 and Fig. 2.

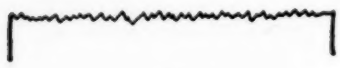


FIG. 1

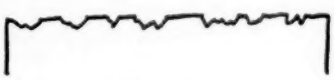


FIG. 2

In Fig. 1, there is a very fine surface with many thousands of hills and valleys and no or at best very few flat surfaces. There is relatively low reflectivity. In Fig. 2 there is really quite a rough surface having high reflectivity because of the many nearly flat sections. Such a surface is found on a bearing—oil is carried in the valleys and the load is carried on the flats.

The perpendicular cross sections of a surface gives much information but a taper section is of greater value due to its inherent magnification. Consider the following Fig. 3.

FIG. 3

If a taper section, of about one to thirty, be made of this sample, much magnification is gained automatically. The result of this taper section is shown diagramatically in Fig. 4.

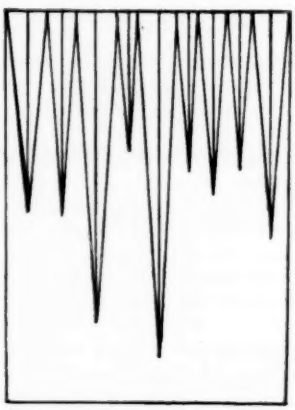


FIG. 4

The taper section for surface measurement is easier in execution and it gives the information desired more easily than any of the others considered here today.

The type of surface which it is possible to obtain on any given surface is dependent to a large measure on the relative hardness of both the material itself and the tool used in working the surface. With the development of new and harder surfaces and cutting agents came the need of a hardness scale that would overcome the deficiencies of the older scales, such as: Moh, Rockwell and Brinnell.

In 1936, Frederick Knoop and his associates at the National Bureau of Standards developed the Knoop scale. This scale makes use of the size of an indented portion of the surface. The indentor is in the form of a carefully lapped elongated 4-sided pyramid made of a diamond. Tables are available for the various loads on the indentor but the 100 gram load seems to be well established.

Both the Brinnell and the Rockwell scales have rather definite upper limits. The Moh scale has fixed points that are far from equidistant. The Knoop scale attempts to overcome the above deficiencies. The following is a table of some fixed points on the Knoop hardness scale:

Fixed Points On The Knoop Hardness Scale

(Load on indenter 100 grams)

Material	Moh	Knoop (K_{100})scale
Diamond	10	8,000–8,500
Boron carbide		2,600–2,900
Silicon carbide		2,320–2,760
Titanium carbide		2,350–2,630
Tungsten titanium carbide		2,050–2,320
Aluminum oxide		1,680–2,100
"Corondum"	9	1,425–2,310
"Kennametal KM"		1,390–1,600
Topaz	8	1,240–1,500
Garnet		1,240–1,440
Spinel		1,190–1,460
"Carboloy"		1,050–1,500
Quartz		710– 790
Hardened tool steel Rockwell C – 60.5		730– 760

Pure oxide refractories are needed in the development and testing of the hard cutting materials listed in the previous table.

To meet demands of industry, a group of special refractories, termed "pure oxides," have been developed. The superior characteristics of these refractories is due in large measure to their freedom from fluxes. They are characterized by being monocrystalline and self-bonded as compared with glass-bonded refractories. The refractory oxides developed, in order of increasing cost per unit of volume, are alumina, magnesia, zirconia, beryllia and thoria.

Table Showing The Characteristics of These "Pure Oxide Refractories"

Refractory	Fusion Point °C.	Stability
Alumina	2,000–2,045	Very stable in oxidizing and reducing atmospheres, at 1700°C. to 1800°C. resistant to all gases except fluorine.
Magnesia	2,800	Ordinarily stable in oxidizing atmospheres, easily reducible at high temperatures, volatilized in oxidizing atmospheres above 2300°C.
Zirconia	2,715	Stable in oxidizing and moderately reducing atmospheres, low thermal conductivity, may have disastrous volume changes on inverting to

		crystalline structure, stabilized by addition of small percentages of lime or magnesia.
Beryllia	2,520	High thermal conductivity, good thermal shock resistance, resistant to high reducing atmospheres, volatilizes in presence of water vapor above 1650°C., expensive.
Thoria	3,050	Very high density, poor thermal shock resistance, radioactive, expensive.

The next speaker of the morning session was Dr. Paul Booder, Director of the Bureau of Visual Science, American Optical Company. The title of the lecture was: "Space Perception." Dr. Booder's rather technical and learned discussion reviewed the known facts about space perception and answered the question, "What is the relationship between physical and visual space perception?" The results are summarized in the following table.

Physical space	Visual space
infinite	finite
no perspective	definite perspective (size constancy good for about 200 feet)

As in all things there is little advance in the art until there is a meteric. A meteric has been developed for visual space perception, it is hyperbolic and non-euclidian.

From the science of visual space perception with the development of a suitable meteric there now emerges four definite values:

1. Possible quantitative measurement of the individual,
2. Improvement of pictorial representation,
3. Improvement of monocular instruments and
4. Value in clinical investigations.

Dr. Norton Masius, Head of the Department of Physics at Worcester Polytechnic Institute was the last speaker of the morning session. His talk was "Physics at WPI."

The problem of the teaching of physics at WPI is in one respect different from the teaching of physics at many other schools: all students get the B.S. degree in some branch of engineering. Because of this one fact, all students are required to take physics. Physics I and Physics II are given in the freshman year. Physics III and Physics IV are taken in the sophomore year.

Physics I	First term—statics, kinematics, dynamics, and properties of fluids.
Physics II	Second term—harmonic motion, waves, sound and heat.
Physics III	Electricity and magnetism.
Physics IV	Light and selected topics.

The division of the available time for the teaching of physics is interesting: all freshmen have two lectures, two recitations and one two-hour laboratory per week. The sophomores have two lectures, two recitations and one three hour laboratory per week and in addition one extra hour for the discussion of laboratory work and an introduction to the theory of errors.

The features of the most interest to the teachers of physics is the relationship between physics and mathematics and the different types of laboratory exercises and the part they play in the instructional scheme. Mathematics is required of all freshmen and sophomors: five recitations per week in the first year and three recitations per week for the sophomores.

The important ideas and concepts in mathematics are introduced as soon as possible. The work is made a bit easier than normally for both trigonometry and solid geometry is an entrance requirement.

There is a general review of trigonometry which is of value in statics and in the resolution of forces. Without any doubt there is some duplication in this scheme but this duplication is thought to be advisable and desirable for one of the aims of the school is "the . . . acquisition of knowledge as a whole." This attempt to coordinate physics and mathematics to produce the "best order" for both subjects "reasonable cooperation . . . is sought rather than forced cooperation . . . ." The concept of rates is reached at the same time in both courses. "At a later stage, namely at the point where the rotational inertia of a body has to be calculated" the physics is ahead of the mathematics. In this case, as in some others, the mathematics is presented in the physics classes. "The treatment of harmonic motion another point where physics and mathematics consider the same topic and where mathematics should be ahead but is not" is the second example where the mathematics is taught in the physics classes. In this case the mathematics is much boiled down. "Thereafter mathematics is always ahead."

As indicated above, the laboratory work at WPI, is also of special interest. There are three types of experiment used in the laboratory:

1. Principle teaching experiments, Type A,
2. Some intermediate experiments, and
3. More complex experiments, Type B.

The requirements of both the Type A and the Type B experiments are usually contradictory:

Type A: 1. simple apparatus is used,
2. obvious method of measurement is used,
3. little accuracy required.

Type B: 1. best apparatus used,
2. indirect or less obvious method of measurement used,
3. great accuracy.

The "large number of type A experiments is one of the principal features of the course in general physics at WPI." In Physics I all of the experiments are of the type A, they are done simultaneously and the principles are discussed in the preceding lecture. Physics II and III is a transition period, as far as the laboratory work is concerned. In Physics IV there are still some of the type A experiments done. These include work on mirrors, lenses, and prisms, etc. The majority of the experiments are, however, of the type B. They are all "done in rotation and concerned with matters that the student has learned earlier."

A distribution of the experiments may be realized from the fact that about fifty experiments are done in Physics I to IV inclusive, about one-half are of Type A, twelve intermediate, and the rest of Type B.

All calculations for the Type A experiments are done in the laboratory, entered on a short experiment form, and handed in before leaving the laboratory. The calculations for the Type B experiment are done out of the laboratory, entered on a longer experiment form, and handed in the following week.

There is continual reviewing every fourth or fifth recitation. All grades are from cumulative examinations given every other week.

During the afternoon session a most interesting and helpful demonstration of the fundamental facts of direct current electrical and magnetic phenomena was presented by Professor K. Mayer of the physics department at WPI. In all the demonstrations the importance of the ease of observing the phenomena was emphasized.

To ease the visual task, apparatus of heroic proportions was improvised, silhouetts of the apparatus were projected on a large screen and large but very light indicators (actually small flags in some cases) were attached to the moving needles or coils.

One element which made the demonstration the success that it was, was the use of low voltage and high current. Some of the demonstrations do not operate

to best advantage unless the current is of the order of twenty to fifty amperes. This is not always available in the high school laboratory.

Experiments demonstrated included the following:

1. Oersted's experiment.
2. Coil carrying a current acts as a magnet.
3. Action and reaction of two coils.
4. Astatic needles, very large knitting needles used.
5. Parallel wires to carry current both in the same and in opposite directions.
6. Double tangent galvanometers.
7. Behavior of permalloy.
8. Consequence poles in a y-shaped magnet.

Under the direction of Mr. W. Roscoe Fletcher, Chairman of the Apparatus Committee, several of the members present demonstrated some home made apparatus of great value.

1. Pin Shearing Bar.

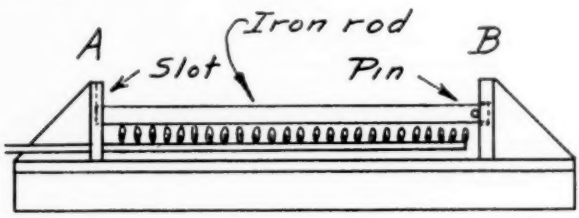


FIG. 5

A rod of iron or tool steel about $\frac{1}{2}$ inch in diameter is supported in a rigid frame of welded and reenforced angle iron. One end of the bar fits in a shallow slot at end *A* in the figure. The other end of the bar passes through a hole in support *B* and has a pin inserted after the bar is in place. The pin may be of hardened steel. The fit of both the rod and the pin must be close. Below the bar is a heating unit made of a copper tube. There are many holes in the top of the tube where many tiny flames heat the bar. On heating the bar, the pin shears. *Caution:* the pieces of the pin may fly about the room.

2. Which Way Will The Spool Roll?

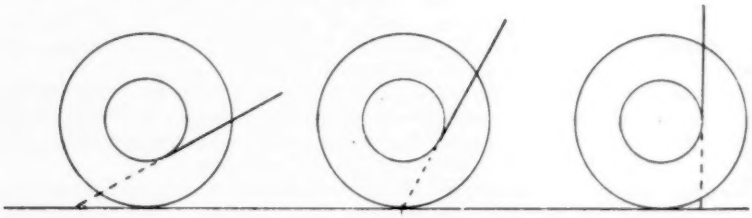


FIG. 6

The apparatus consists of a large spool, such as is used for wire, and a short length of string one end of which is attached to the spool. This is clearly shown in the figure. A lively discussion will result when the question, "Which way will it roll when the string is pulled?" is asked. Until there is some careful thinking about view *B* there will be little agreement as to the results to be expected or explanation as to why the observed results.

3. Use for the old toy opaque projector.

Replace the low wattage lamps with 500 watt projection bulbs and line the

housing with sheets of asbestos. Mount a small electric fan in a suitable housing either at the side or at the top of the projector. Provide holes through which air can have a complete path from the outside through the projector and out again. Yes, it does get hot but it works well even in a room that is not completely dark.

4. Signal generator for finding the source of trouble in a radio.

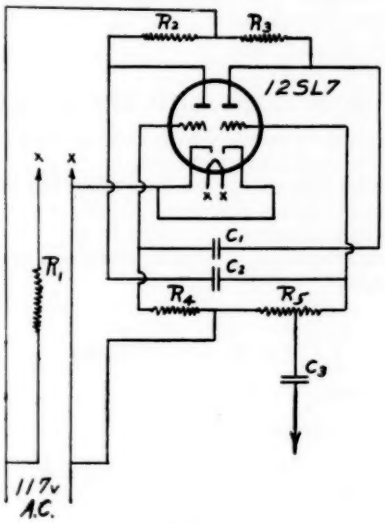


FIG. 7

R_1	760 ohm resistor
R_2 R_3	22000 ohm resistor
R_4	10000 ohm resistor
R_5	10000 ohm potentiometer
C_1 C_2	.01 microfarad 200 volt condenser
C_3	30 micromicrofarad 600 volt mica condenser

As physics teachers, we should have some ideas as to how to find the trouble with a radio set. With the simple multivibrator indicated above, the faults in many radios and amplifiers may be found easily and quickly. Simply start with the wires to the voice coil of the speaker and work back in the wiring of the set toward the antenna. Touch the well sharpened point of the probe (in an insulated handle) to the electrical components of the circuit. Almost invariably there will be found a place where the signal does not come through. The signal is a distinct roar or rattle. The fault or trouble is found between the last place where the signal is heard and the first place where the signal is lost. The signal will get weaker and weaker as the worker applies the probe nearer and nearer to the antenna end or input end of the radio or amplifier.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed.

Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the depariment desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2126, 8. *S. E. Field, Ironwood, Mich.*

2125, 30. *W. R. Talbot, Jefferson City, Mo.*

2126. *Milton D. Eulenberg, Chicago, Ill., Tom Estel, Mt. Pleasant, Iowa, Maurice Lee Holder, Baltimore, Md., Steve R. Domen, Indiana, Pa.*

2126, 30. *V. C. Bailey, Evansville, Ind.*

2118, 20. *Margaret Zwecky, Oak Park, Ill.*

2126. *Helen Angela, Jackson, Miss.*

2131. *Proposed by Daisy Caryell, Edmonton, Canada.*

By inspection show that one root of $x^3+3x=a^2-a^{-2}$ is $x=a-a^{-1}$.

Solution by C. W. Trigg, Los Angeles City College

Since $(a-a^{-1})^3$ contains a^3, which does not appear in the right hand member of the equation, it would appear that $x=a-a^{-1}$ is not in general a root of the equation. In fact, upon substituting this root in the equation and simplifying, we have

$$(a-a^{-1})\left[(a+a^{-1})^2-(a+a^{-1})-1\right]=0.$$

Therefore, $x=a-a^{-1}$ is a root of the equation only if

$$a=\pm 1,\ \tfrac{1}{4}\left[1\pm\sqrt{5}+\sqrt{\pm 2\sqrt{5}-10}\right] \quad \text{or} \quad \tfrac{1}{4}\left[1\pm\sqrt{5}-\sqrt{\pm 2\sqrt{5}-10}\right].$$

It may be observed that the equation

$$x^3+3x=a^3-a^{-3}$$

may be written in the form

$$x(x^2+3)=(a-a^{-1})(a^2+1+a^{-2}).$$

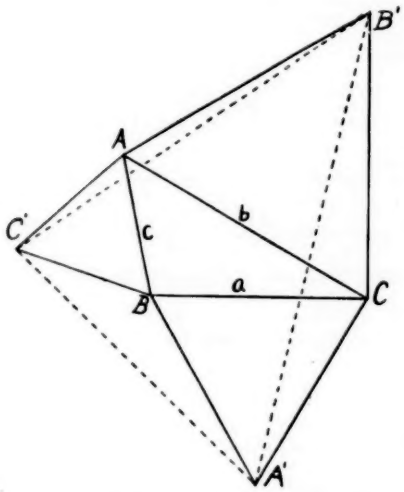
Obviously $x=a-a^{-1}$ satisfies this equation.

Solutions were also offered by Max Beberman, Shanks Village, N. Y.; Hugo Brandt, College Mound, Md.; Norman Anning, University of Mich.; Ben K. Gold, Los Angeles, Calif.; W. R. Talbot, Jefferson City, Mo.; Mildred Hopkins, Kankakee, Ill.; Norma Sleight, Winnetka, Ill.

2132. *Proposed by V. C. Bailey, Evansville, Indiana.*

On the sides of triangle ABC equilateral triangles $A'BC$, $B'CA$, and $C'AB$ are constructed externally. Prove that

$$\triangle A'B'C' = \frac{5}{2}\triangle ABC + \frac{\sqrt{3}}{8}(a^2+b^2+c^2).$$



Solution by the proposer

$$\triangle C'AB' = 1/2bc \sin(120°+A) = 1/4bc(\sqrt{3}\cos A - \sin A)$$
$$\triangle B'CA' = 1/2ab \sin(120°+C) = 1/4ab(\sqrt{3}\cos C - \sin C)$$
$$\triangle A'BC' = 1/2ac \sin(240°-B) = 1/4ac(-\sqrt{3}\cos B + \sin B)$$
$$\triangle A'B'C' = \triangle ABC + \triangle AB'C + \triangle CA'B + \triangle BC'A - \triangle C'AB' - \triangle B'CA' + \triangle A'BC'$$
$$\triangle A'B'C' = \triangle ABC + b^2/4\cdot\sqrt{3} + a^2/4\cdot\sqrt{3} + c^2/4\cdot\sqrt{3} - bc/4(\sqrt{3}\cos A - \sin A) - ab/4(\sqrt{3}\cos C - \sin C) + ac/4(-\sqrt{3}\cos B + \sin B)$$
$$\triangle A'B'C' = \triangle ABC + \sqrt{3}/4(a^2+b^2+c^2) - \sqrt{3}/4(bc\cos A + ab\cos C + ac\cos B) + 1/4bc\sin A + 1/4ab\sin C + 1/4ac\sin B$$
$$\triangle A'B'C' = \triangle ABC + \sqrt{3}/4(a^2+b^2+c^2) - 2\sqrt{3}/8(bc\cos A + ab\cos C + ac\cos B) + 1/2\triangle ABC + 1/2\triangle ABC + 1/2\triangle ABC$$
$$\triangle A'B'C' = 5/2\triangle ABC + \sqrt{3}/4(a^2+b^2+c^2) - \sqrt{3}/8b(c\cos A + a\cos C) - \sqrt{3}/8c(b\cos A + a\cos B) - \sqrt{3}/8a(b\cos C + c\cos B)$$
$$\triangle A'B'C' = 5/2\triangle ABC + \sqrt{3}/4(a^2+b^2+c^2) - \sqrt{3}/8(b^2+c^2+a^2)$$
$$\triangle A'B'C' = 5/2\triangle ABC + \sqrt{3}/8(a^2+b^2+c^2)$$

Solutions were also offered by W. R. Talbot, Jefferson City, Mo.; C. W. Trigg, Los Angeles, Calif.; Steve R. Domen, Indiana, Pa.; Max Beberman, Shanks Village, N. Y.; the Proposer; Hugo Brandt, Univ. of Md.

2133. *Proposed by William W. Johnson, Cleveland.*

This problem first appeared as 1673. In both issues it was printed incorrectly. A correct statement with solution by the author is here given.

Solve the equation,

$$\frac{(x-a+b)^2}{(x+a-b)^2}=\left(1-\frac{2x}{a}\right)^2+\left(1+\frac{2x}{b}\right)^2-9.$$

This may be written,

$$\frac{(x-a+b)^2}{(x+a-b)^2}=\left(\frac{a-2x}{a}\right)^2+\left(\frac{b+2x}{b}\right)^2-9.$$

Clearing of fractions,

(4) (1) (2) (3)

$$a^2b^2(x-a+b)^2=(x+a-b)^2b^2(a-2x)^2+(x+a-b)^2a^2(b+2x)^2-9(x+a-b)^2a^2b^2$$

Expanding and simplifying one obtains after much labor this fourth degree equation.

$$(a^2+b^2)x^4+(2a^3-a^2b+ab^2-2b^3)x^3+(a^4-4a^2b^2+b^4)x^2+(a^4b-6a^3b^2+6a^2b^3-ab^4)x$$
$$-2a^4b^2+4a^3b^3-2a^2b^4=0.$$

Factoring,

$$[x^2+(a-b)x-ab][(a^2+b^2)x^2+(a^3-b^3)x+2a^3b-4a^2b^2+2ab^3]=0.$$

The first factor gives b and $-a$ as solutions. The other solutions are too complicated for printing.—EDITOR).

2134. *Proposed by V. C. Bailey, Evansville, Ind.*

If the sides of a triangle are in arithmetic progression and if the greatest angle exceeds the least by 90°, show that the sides are proportional to

$$\sqrt{7}+1,\ \sqrt{7},\ \sqrt{7}-1.$$

Solution by Adrian Struyk, Paterson, N. J.

Since the sides a, b, c of triangle ABC are in arithmetic progression, let them be $b+d$, b, $b-d$ respectively. Dividing by d, and putting $k=b/d$, we obtain a similar triangle, having the same angles, but with sides $k+1$, k, $k-1$. For the angles A, B, C opposite these sides we may write $C+90°$, $90°-2C$, C respectively, making the greatest exceed the least by 90°, and making the sum of all three 180°. Then, by the Sine Law,

$$\frac{k+1}{\sin(C+90°)}=\frac{k-1}{\sin C},\quad \text{or}\quad \frac{k+1}{\cos C}=\frac{k-1}{\sin C}. \tag{1}$$

By the Cosine Law

$$\cos C=\frac{k^2+(k+1)^2-(k-1)^2}{2k(k+1)}\quad \text{or}\quad \cos C=\frac{4+k}{2(k+1)}; \tag{2}$$

$$\cos(C+90°)=-\sin C=\frac{k^2+(k-1)^2-(k+1)^2}{2k(k-1)}\quad \text{or}\quad \sin C=\frac{4-k}{2(k-1)}. \tag{3}$$

From (1), (2), (3):

$$\frac{(k+1)^2}{4+k}=\frac{(k-1)^2}{4-k},$$

whence $k=\sqrt{7}$. Therefore the sides of triangle ABC are proportional to $\sqrt{7}+1$, $\sqrt{7}$, $\sqrt{7}-1$.

Solutions were also offered by Norman Anning, University of Mich.; Howard Somers, Toronto; W. R. Talbot, Jefferson City, Mo.; B. K. Gold, Los Angeles, Calif.; and the Proposer; C. W. Trigg, Los Angeles, Calif.; Hugo Brandt, Univ. of Md.

2135. *Proposed by W. R. Warne, Alton, Ill.*

For $x^3+px^2+qx+r=0$ with roots α, β, γ find

$$\sum \frac{\alpha^2+\beta^2}{\alpha\beta}.$$

Solution by R. E. Horton, Los Angeles City College

$$\sum \frac{\alpha^2+\beta^2}{\alpha\beta}=\frac{\alpha^2+\beta^2}{\alpha\beta}+\frac{\beta^2+\gamma^2}{\beta\gamma}+\frac{\gamma^2+\alpha^2}{\gamma\alpha}.$$

Over a common denominator this becomes

$$\frac{\alpha^2\beta+\alpha^2\gamma+\beta^2\alpha+\beta^2\gamma+\gamma^2\alpha+\gamma^2\beta}{\alpha\beta\gamma}$$

which can be factored into the form

$$\frac{(\alpha\beta+\beta\gamma+\gamma\alpha)(\alpha+\beta+\gamma)-3\alpha\beta\gamma}{\alpha\beta\gamma}.$$

Now

$$-p=\alpha+\beta+\gamma$$
$$q=\alpha\beta+\beta\gamma+\gamma\alpha$$
$$-r=\alpha\beta\gamma$$

Therefore

$$\sum \frac{\alpha^2+\beta^2}{\alpha\beta}=\frac{pq-3r}{r}.$$

Solutions were also offered by Helen Angela, Jackson, Mich.; C. W. Trigg, Los Angeles, Calif.; Harold A. Gouss, Newark, N. J.; Mildred Hopkins, Kankakee, Ill.; Robert E. Horton, Los Angeles, Calif.; Max Beberman, Shanks Village, N. Y.; Adrian Struyk, Paterson, N. J.; Roy E. Wild, Chicago, Ill.; B. K. Gold, Los Angeles, Calif.; V. C. Bailey, Evansville, Ind.; W. R. Talbot, Jefferson City, Mo.; Richard Van Vanken, Mt. Pleasant, Iowa; Norman Anning, University of Mich.; Hugo Brandt, Univ. of Md.

2136. *Proposed by C. W. Trigg, Los Angeles.*

If $f(x)=x^3+14x^2+23x+a=0$ and $g(x)=x^3+8x^2-7x+b=0$ have two roots in common solve each equation.

Solution by J. Slavin, Brooklyn, N. Y.

Let the roots of $f(x)=0$ be r, s and t and those of $g(x)=0$ be r, s and m. Using the relation between coefficients and roots, we obtain

(1) $$r+s+t=-14$$

and

(2) $$r+s+m=-8$$

and upon subtracting (2) from (1) we have

(3) $$t-m=-6$$

and furthermore we have the equations,

(4) $$rs+rt+st=23$$

and

(5) $$rs+rm+sm=-7.$$

Subtracting (5) from (4) and factoring we obtain

(6) $$r(t-m)+s(t-m)=30.$$

From (6) and (3) we obtain $r+s=-5$ and using above with (1) and (2) we have $t=-9$ and $m=-3$.

Using the factor theorem we obtain $a=-189$ and $b=-66$.

Removing the known roots $t=-9$ and $m=-3$ from the given equations we find that each is depressed into the same second degree equation,

$$x^2+5x-22=0$$

so that the roots of $f(x)=0$ and of $g(x)=0$ are

$$-9,\ \frac{-5\pm\sqrt{113}}{2} \quad \text{and} \quad -3,\ \frac{-5\pm\sqrt{113}}{2}$$

respectively.

Solutions were also offered by C. W. Trigg, Los Angeles, Calif.; C. F. Holmes, Washington, D. C.; Helen Angela, Jackson, Mich.; Max Beberman, Shanks Village, N. Y.; Adrian Struyk, Paterson, N. J.; R. E. Horton, Los Angeles, Calif.; B. K. Gold, Los Angeles, Calif.; V. C. Bailey, Evansville, Ind.; Richard Van Vranken, Mt. Pleasant, Iowa; W. R. Talbot, Jefferson City, Mo.; Walter L. Smith, Long Beach, Calif.; Hugo Brandt, Univ. of Md.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

2119, 20, 4. *Harrison Roth, New York.*

2123, 4. *Alan Berndt, New York.*

2119. *D. Berkawitz, New York.*

2119, 20, 3, 4. *Jan de Boer, Leiden, Holland.*

PROBLEMS FOR SOLUTION

2149. *Proposed by Norman Anning, University of Michigan.*

Show that one of these equalities is an identity and solve the other:

$$\sin x \sin 4x+\sin 2x \sin 5x=\sin 3x \sin 6x$$

$$\sin x \sin 4x+\sin 2x \sin 7x=\sin 3x \sin 6x$$

2150. *Proposed by W. R. Talbot, Jefferson City, Mo.*

The hypotenuse of a primitive right triangle of integral sides becomes the base for a larger primitive right triangle of integral sides. This process may be re-

peated any number of times. If the first triangle meets the condition imposed on the subsequent triangles, show that the area of any of these triangles is 6 times the sum of the squares of the first n integers, where n is the largest integral square root in half the unrepeated side of the triangle.

2151. *Proposed by H. Donald John, Baltimore, Md.*

At the extremity of chord AB of a circle, two tangents are drawn to R. Though point P of chord AB a secant is drawn meeting the tangents at M and N. Prove that $PM = PN$.

2152. *Proposed by Orville F. Barcus, Philadelphia.*

What value of n will make $n^2+324n+307=r^2$, where r is an integer. Is there a general solution?

2153. *Proposed by William L. Schaaf, Brooklyn.*

Derive a formula for the area of a segment of a circle in terms of the height, h, and the length, w, of the chord.

2154. *Proposed by W. H. Cleveland, Meridian, Miss.*

Show that $3^{2n}+7$ is divisible by 8.

BOOKS AND PAMPHLETS RECEIVED

GEOMETRY—A FIRST COURSE, by Paul L. Trump, *Head of the Department of Mathematics at the Wisconsin High School, Madison, Wisconsin.* Cloth. Pages xvi+496. 13.5×21 cm. 1949. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $2.88.

MATHEMATICS FOR ELECTRICIANS, by Martin Kuehn, *Principal of Technical High School, Buffalo, New York.* Third Edition. Cloth. Pages xi+372. 13.5×20 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.80.

PRACTICAL SHOP MATHEMATICS. VOLUME II—ADVANCED, by John H. Wolfe, Sc.D., *Formerly Director of Apprentice Training, Ford Motor Company,* and Everett R. Phelps, Ph.D., *Professor of Physics, Wayne University.* Third Edition. Cloth. Pages xiv+356. 12×19.5 cm. 1949. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.60.

COMPARATIVE ANATOMY, by Leverett A. Adams, *University of Illinois,* and Samuel Eddy, *University of Minnesota.* Cloth. Pages vii+520. 14.5×22 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

AN INTRODUCTION TO CHEMICAL SCIENCE, by W. H. Hatcher, *Professor of Chemistry, McGill University.* Second Edition. Cloth. Pages x+449. 13.5×21.5 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.00.

PHYSICS IN THE MODERN WORLD, by Henry Semat, Ph.D., *Associate Professor of Physics, The City College, College of the City of New York.* Cloth. Pages xiii +434. 15×23 cm. 1949. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $5.00.

SLOBIN AND WILBUR'S FRESHMAN MATHEMATICS, Third Edition, Revised by C. V. Newsom, *Assistant Commissioner for Higher Education, The State of*

New York. Cloth. Pages xiv+559. 15×22.5 cm. 1949. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $5.00.

ALGEBRA, BOOK ONE, ELEMENTARY COURSE, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana*. Cloth. Pages xi+580. 14×20.5 cm. 1949. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.12.

A CONCISE ENCYCLOPEDIA OF WORLD TIMBERS, by F. H. Titmuss. Cloth. Pages v+156. 14×21.5 cm. 1949. Philosophical Library, Inc., 15 East 40th Street, New York, N. Y. Price $4.75.

NUMBERS WE SEE, by Anita Riess, Maurice L. Harting, and Catharine Mahoney. Cloth. 162 pages. 19.5×26 cm. 1948. Scott, Foresman and Company, 433 East Erie Street, Chicago 11, Ill. Price $1.32.

ARITHMETIC FOR TEACHER-TRAINING CLASSES, by E. H. Taylor, *Professor of Mathematics, Emeritus, Eastern Illinois State Teachers College*, and C. N. Mills, *Professor of Mathematics, Illinois State Normal University*. Third Edition. Cloth. Pages vi+441. 13×20 cm. 1949. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $3.00.

A WORLD VIEW, by Clarence Woodrow Sorensen, *Department of Geography, Illinois State Normal University*. Cloth. 410 pages. 20×26.5 cm. 1949. Silver Burdett Company, 45 East 17th Street, New York 3, N. Y.

PRACTICAL BIOLOGY WORKBOOK, by Edwin F. Sanders, *Formerly of Washington Park High School, Racine, Wisconsin*, and Philip Goldstein, *Biology Department, Bronx High School of Science, New York, N. Y.* Paper. Pages viii+130. 18×27.5 cm. 1949. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

LABORATORY OUTLINES AND NOTEBOOK FOR ORGANIC CHEMISTRY, by Cecil E. Boord, *Professor of Organic Chemistry, The Ohio State University*, Wallace R. Brode, *Associate Director, National Bureau of Standards*, and Roy G. Bossert, *Associate Professor of Chemistry, Ohio Wesleyan University*. Second Edition. Paper. Pages xi+282. 18.5×27 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

PINEVILLE HIGH MEETS THE CHALLENGE. A story of the effects of hookworm and ways of treating and preventing the disease, by Dorothy C. Stephens. Paper. 54 pages. 14×21.5 cm. 1948. Project in Applied Economics, College of Education, University of Florida, Gainesville, Fla. Price 15 cents.

RODDY, THE RAT. A story of the spread of typhus fever and of ways of getting rid of rats, by George S. Bote, *Typhus Consultant, Florida State Board of Health*, and Dorothy Stephens Laird, *Instructor in Education, University of Florida*. Paper. 72 pages. 15×22.5 cm. 1949. Project of Applied Economics, College of Education, University of Florida, Gainesville, Fla. Price 15 cents.

PLANTS AND GARDENS. Spring, 1949, Volume 5, Number 1. Paper. 64 pages. 15×23 cm. Brooklyn Botanic Garden, Brooklyn 25, N. Y.

ANNUAL REPORT, EASTMAN KODAK COMPANY. Paper. 36 pages. 21.5×28 cm. 1948. Eastman Kodak Company, 343 State Street, Rochester 4, N. Y.

The actual fact is that this day Opportunity not only knocks at your door but is playing an anvil chorus on every Man's door, and then lays for the owner around the corner with a club.

—ELBERT HUBBARD

BOOK REVIEWS

MICROBES MILITANT; A CHALLENGE TO MAN. Frederick Eberson, *Assistant Chief, Laboratory Service, Veterans Administration Medical Teaching Group, Kennedy Hospital, Memphis, Tennessee.* Cloth. Pages ix+401. 15×23 cm. Twenty-six illustrations. Revised edition, 1948. The Roland Press Co. New York. Price $4.50.

The sub-title of this book is "The story of modern preventive medicine and control of infectious diseases." It is listed as "a volume of the humanizing science series" edited by Jaques Cattell and its first issue was in 1941 under the title "The Microbes' Challenge."

The author was formerly director of laboratories and pathologist in the Galliger Hospital, Washington, D. C.

An abbreviated catalogue of the chapter titles (there are thirteen of them) gives a suggestion of the unfolding story. Starting with "Microbes have a way of living" there follows "The way of the parasite" and the quirks of microbes are further presented in a chapter on, "Microbes are changeable." Chapter six introduces chemicals as potent controls in microbe warfare and antibiotics are especially spot-lighted in this connection. Borderline aspects of microbe activity are considered under such captions as: "Animate or lifeless," "Virus riddles," and "Little microbe, what next?" The closing chapters, "Epidemics to order" and "The challenge" attempt a sort of qualitative evaluation of the microbic situation as of 1948.

As the reviewer perused the 400 pages of this book he, from time to time, had the thought "No place to hide" from these. However, the author, in his preface, somewhat prepared the reader for this attitude when he said, "To think for a moment that our conquest (of germ infection) has been one sided is far from the truth and it would be rash to prophesy . . . a complete and lasting victory over . . . (this) invisible enemy."

Perhaps it is well for us to be sensitive to the uncertainties of our future as influenced by microbes as well as by nuclear fission. In this volume the intelligent people, who wish to understand such matters, will find a readable and enlightening exposition of both the achievements and opportunities for advance yet to be realized in this field.

B. CLIFFORD HENDRICKS
University of Nebraska, Lincoln

ARITHMETIC TEACHING TECHNIQUES, An In-Service Survey and Study Conducted by a Committee on Arithmetic Teaching Techniques with the cooperation of the District Superintendents, Principals, and Teachers in the Chicago Public Elementary Schools. Committee: Joseph J. Urbancek, *Chairman Mathematics Department, Chicago Teachers College;* J. T. Johnson, *Former Chairman Mathematics Department, Chicago Teachers College;* Don C. Rogers, *Assistant Superintendent in Charge of Elementary Education, Chairman.* Paper. Pages x+347. 17×25 cm. Published by the Board of Education, City of Chicago.

This study reports difficulties encountered by teachers of arithmetic together with teaching techniques which other teachers have found of value in overcoming these difficulties. Difficulties reported by teachers in more than three hundred elementary schools were classified into 29 categories, which were then grouped into seven major classifications: Vocabulary, Mechanics of Reading, Arithmetical, Teaching, Textbook, Problem Analysis, and Reasoning Difficulties.

Approximately 1300 techniques for meeting difficulties were reported; these, were divided into three groups according to the grade level for which the technique was intended. Each technique in a group was then rated by a selected jury of nine teachers, a five point scale being used in the ratings. The book reports techniques whose composite rating was above the average. The description of

the technique is, in general, in the words of the teacher who reported it. This makes for considerable inconsistency in style, but does retain the personality of the teacher.

The final chapter reports a study of the nature of problem solving in arithmetic. This chapter would very distinctly seem to be of less value to the class room teacher than the rest of the book.

A considerable portion of the material is by no means new—much of it has appeared in magazine articles and text books. On the other hand, there are many suggestions not readily found in print. It would be hard to find any single publication containing even half of this material. Without doubt, every teacher who reads the book will agree whole-heartedly in spots, and disagree violently in other places. To illustrate: the reviewer was exceptionally pleased with part D under Problem Analysis—Failure to Estimate Answers; he was displeased with a vocabulary quiz on page 16 (314 should be 3.14, the definition of "round off" seems poor, and there are two possible replies to the phrase "the distance around"). On page 74 it is stated that a decimal point is the only time when an *and* is used in reading numbers—this fails to agree with the many statements that arithmetic teaching should fit in with the child's daily experiences (while reading this very page, the announcer on the radio read the figures "six hundred and twenty-five"). One other example: in solving "How many half inches are there in 6 inches" do you add, subtract, multiply, or divide? (page 6). Will all teachers agree that there is a unique answer here?

There is some duplication of material, and the classification into the various categories at times seems forced if not somewhat inconsistent. One might wonder if a larger teacher board of evaluation might have been advisable; a more permanent type of binding could be suggested; but these and the items mentioned previously are relatively minor criticisms. The book as a whole is a veritable gold-mine of teaching techniques. If it is not possible for individual teachers to have a personal copy, certainly this book should be in the library of every teacher training institution.

CECIL B. READ
University of Wichita

ANALYTIC GEOMETRY, REVISED EDITION, by Charles H. Sisam, *Emeritus Professor of Mathematics, Colorado College.* Cloth. Pages xvi+304. 14×20 cm. Henry Holt and Company, New York, New York. Price $2.40.

This is a revised edition of a text which has had considerable popularity. In some cases a revised edition has some of the exercises changed, but others remain identical. In this revision practically every exercise has been revised, and the number of problems has in many places been increased. The current revision places the material on polar coordinates in a single chapter, rather than at intervals throughout the text. Other changes are relatively minor: the starred sections which might be omitted vary slightly in the two editions; there is a new method of developing the formula for the area of a plane triangle; more emphasis is given to the equations of conics with axes parallel to the coordinate axes; the point of division formula in three dimensions is omitted; there are some minor changes in the order of topics.

The text is rather complete, the material on higher plane curves is exceptionally well presented; there is a chapter on tangents, normals, diameters, poles, and polars; treatment of empirical equations is quite thorough. As is the case with other texts by this author, the material is well written, and should appeal to both teacher and student. The treatment would be classified as somewhat traditional, with ample material for a fairly extensive course, yet so arranged as to facilitate selection of basic material for a brief course. The book is definitely of top rank, and should not be omitted from consideration when a change in text is contemplated.

C. B. READ

COLLEGE ALGEBRA by Edward A. Cameron and Edward T. Browne, *Professors of Mathematics, The University of North Carolina.* Cloth. Pages x+406. 15×21.5 cm. 1949. Henry Holt and Company, 257 Fourth Avenue, New York 10, New York. Price $3.00.

This is another college algebra text covering material which is somewhat traditional; it does not seem to be outstandingly bad nor do there seem to be any features which would make it outstandingly good. The text is worthy of consideration when a new adoption is contemplated. In general the supply of problems is ample.

Certain features deserve favorable comment: definitions are usually stated in rigorous terms (i.e., the exclusion of zero as a base in defining negative exponents); the general form of statement of Descartes' Rule of Signs; short historical references. Certain other features tend to detract from the over all value: a statement on page 187 would imply that in a proof by mathematical induction the theorem must be true for the integer one. (This would prohibit using mathematical induction for any proof involving a polygon of n sides); on page 182 it does not follow from the preceding material that $\sqrt{2}$ and π are infinite non-repeating decimals; on page 194 one wonders how the student is to know that proper conditions are satisfied which allow approximations by the first few terms of the binomial expansion; the statement on page 289 that the mantissa of the logarithm of any number is independent of the position of the decimal point does not agree with the definition of a mantissa previously given.

CECIL B. READ

OUTLINE OF THE HISTORY OF MATHEMATICS by Raymond Clair Archibald, *Professor of Mathematics, Emeritus, Brown University,* Sixth Edition revised and enlarged. The second Herbert Ellsworth Slaught Memorial paper. Paper. Pages 114. 18×25.5 cm. Published as a supplement to the American Mathematical Monthly, January, 1949.

This is the latest edition of a work which has had well merited popularity. It is far more than an outline in the usual meaning of that term, it is an extremely readable history of mathematics. The treatment is by chronological periods with special emphasis on important persons and their contributions.

The book starts with a brief synopsis; this is followed by some 50 pages of reading material and about the same number of pages entitled "literature list and notes." This last section offers many possibilities for further reading and study. This new edition is of value not only because previous editions have not been available but because of new material, as for example, that relating to Babylonian mathematics and amplification of the treatment of astronomy.

This work is not only one of the best brief texts in existence but since it is relatively inexpensive it should not be omitted from any high school or college library which purports to have material on the history of mathematics. The index of names now indexes dates which were not found in some of the earlier editions. One might wish that an index of subjects was also included.

CECIL B. READ

THE CHEMICAL ARTS OF OLD CHINA, by Li Ch'iao-p'ing, *Professor of Chemistry, National Northeastern University, Mukden, China.* Cloth. Pages viii+215. 15×23 cm. 1948. Journal of Chemical Education, Easton, Pennsylvania. Price $5.00.

"The Chemical Arts of Old China" will be of interest to students of chemistry and its history, sinologists, students of the culture, of the economics, and of the arts and crafts of Asia. It covers a field which is not covered by any other book in English.

The book discusses Chinese alchemy; ceramic industries; lacquers and lacquering; incense, essential oils, and cosmetics; and many other topics.

The book abounds in pen and brush drawings and halftone illustrations. The end pages were done in color by a famous Chinese artist. Chinese characters are used throughout the book and Chinese equivalents are given to English chemical terms. To illustrate let me quote a passage from the book: "The Chinese had a theory to interpret natural phenomena, and reduce their apparent complexity to simple, unifying terms. This theory, like the old Chinese theory of medicine, is actually philosophical rather than scientific. All the important chemical phenomena are interpreted through the so-called 'yin' or the negative element, and 'yang,' or the positive element, and sometimes also through the so-called 'wu-hsing' of five 'elements'—metal, wood, water, fire, and earth."

The book was written for the purpose of describing ancient Chinese chemistry in terms of theory and method. The book accomplishes this purpose in an interesting style, lavishly supplemented by pen and brush drawings. It is a unique book and highly interesting for both the layman and the chemist.

KENNETH E. ANDERSON
University of Kansas
Lawrence, Kan.

KINETICS OF CHEMICAL CHANGE IN SOLUTION, by Edward S. Amis, *Professor of Chemistry, University of Arkansas.* Cloth. Pages ix+332. 14×21 cm. 1949. The Macmillan Company, New York. Price $5.00.

This book gives the student a thorough training in the subject of rate processes in solution. The opening pages acquaint the student with concepts of the order of reaction, the determination of the order of a reaction, and the basic equation of Arrhenius. Building on these concepts and theories in regard to the coefficients of ions in solution and of dielectric constants of liquids and polar moments of molecules, the student is introduced to more complex ideas and theories such as the Brönsted-Christiansen-Scatchard equation, the effect of changing ionic strength, and homogeneous catalysis.

Although the book is designed as a text, it would constitute a worthwhile addition to the bookshelf of any chemist interested in the kinetics of chemical changes.

It is a thorough and comprehensive book but lucid and readable.

KENNETH E. ANDERSON

THE FUNDAMENTALS OF COLLEGE CHEMISTRY, by G. Brooks King, *Professor of Chemistry, The State College of Washington, Pullman, Washington,* and William E. Caldwell, *Professor of Chemistry and Chemical Engineering, Oregon State College, Corvallis, Oregon.* Cloth. Pages viii+536. 14×22 cm 1949. American Book Company, Illinois. Price $4.00.

This is a concise and orderly treatment of the fundamentals of general chemistry on the college level. The primary purpose of this text is to present the basic facts and principles of science as clearly and simply as possible. Although the text is designed for students without previous training in chemistry, it is sufficiently flexible to be used with those students who have had previous training in chemistry.

All the concepts as presented in this text are strictly up-to-date. The chapter on "Radioactivity and Nuclear Changes" is an illustration of this statement. This particular chapter discusses the disintegration of atoms as it occurs in radioactive elements and then discusses artificial radioactivity, atomic energy, and the atomic bomb.

Each chapter builds upon the previous one in a psychologically sound order. It is written in a manner which stresses understanding on the part of the student. The exercises at the end of each chapter will facilitate review by both student and teacher.

The text is thoroughly substantial and meets the purposes for which it was written.

KENNETH E. ANDERSON

A CONCISE HISTORY OF MATHEMATICS, by Dirk J. Struik, *Professor of Mathematics at the Massachusetts Institute of Technology*. Cloth. Pages xviii+299, 10.5×17 cm. Two volumes. Dover Publications, Inc., 1780 Broadway, New York 19, New York.

In these two small volumes Prof. Struik has succeeded to a remarkable degree in giving the reader a panoramic view of the development of mathematics from its earliest recorded beginnings to about 1900. His account, brief though it is, manages to do much more than to merely record mathematical discoveries in their chronological order. The constant emphasis on the effects of contemporary civilization on mathematical thinking provides the necessary historical orientation and continuity. As the record unfolds, we are able to discern the slow shift in the accent of man's thinking from "how" to obtain a certain result to "why" the method used is correct. We see how the long controversy between authority on one hand and reason on the other finally resolved itself into an appreciation of the necessity for carefully stated premises, and definitions upon which rigorous demonstrations could be founded.

Parallel with this development Prof. Struik describes the evolution of mathematical symbolism pointing out that "New results have often become possible only because of a new mode writing." As he proceeds to trace the profound relation between content and form we see our modern notation emerge and gradually gain general acceptance.

As the exposition proceeds it tends to emphasize persons and schools rather than subjects. The titans of the eighteenth and nineteenth centuries dominate the somewhat longer second volume. They forged new mathematical tools in their efforts to solve basic problems in other sciences, notably astronomy and physics. Their heroic accomplishments are seen, in the long view, as the culmination of the work of many unknown men over many years.

This short history should be a worthwhile addition to any mathematics library. Both high school and college students should find it readable and interesting.

FRANK B. ALLEN
Lyons Township High School
La Grange, Illinois

THE FACE OF THE MOON, by Ralph B. Baldwin, *East Grand Rapids, Michigan*. Cloth. Pages xiv+239. 16.5×24 cm. 1949. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $5.00.

This is a book for the professionally trained man—the astronomer, the geologist, the meteorologist. Only a few laymen will read and enjoy it. Its principal idea is to account for the extremely rough surface of the moon. The author first briefly examines the various processes previously suggested, then discards all but one—the impact of meteorites. He discusses the great Arizona meteorite crater, those in Australia, Siberia, and numerous others in great detail. He also studies man-made explosion pits, such as some of the pitted areas in World War 2. He compares these with the pits on the moon and gives what he considers to be a fair estimate of the amount of material moved and the size and velocity of the projectile or meteorite required to move it. He studies the lava flows on the moon and their relation to the partially filled pits or those possibly completely covered. One chapter studies the atmosphere of the moon, but shows it to be so rare that its effect is negligible compared to the smoothing effect of the earth's atmosphere. But he shows the earth to be subject to the same battering by meteorites as the moon has been. The great difference is that effects on the face of the moon are preserved by want of an atmosphere while on earth the scars of meteorites of past ages are washed away and covered up by atmosphere and hydrosphere; but the bombardment is as frequent and as effective here as on the face of the moon.

G. W. W.

BOY'S BOOK OF SNAKES, HOW TO RECOGNIZE AND UNDERSTAND THEM, by Percy A. Morris, *Chief Preparator, Peabody Museum of Natural History, New Haven.* Cloth. Pages viii+185. 15.5×23.5 cm. 1948. The Ronald Press Company, 15 E. 26th Street, New York 10, N. Y. Price $3.00.

Here is a book for young and old, especially for those who regard all snakes as the incarnation of Satan. It gives in very brief form the general appearance, size, color, habitat, range, food, and habits of all snakes of all parts of the world. Another interesting item told for each type is whether it gives birth to young or deposits eggs; also the size of the brood is given, ranging from a dozen or less to large broods of sixty or seventy. Many will be surprised to learn that a snake is totally deaf, that its forked tongue is not a "stinger" but an organ to aid the sense of smell. The second chapter on the "False Lore of Snakes" tells many of the commonly believed stories and gives the evidence which proves them false. The classification which follows is not for the trained scientist but for the average reader. Four chapters discuss the harmless snakes of America on the basis of the environment where they are found. First are the snakes of gardens and barn yards, second those of fields and pastures, third the snakes of wooded country, and fourth those of swamps and ponds. Chapter seven discusses the poisonous snakes of the United States, where of course the most of the space is given to the various types of rattlesnakes. A first-aid treatment for snakebite closes the chapter. One chapter is given to a discussion of the nonpoisonous snakes of other lands and a chapter to the poisonous snakes. In each case much must be crowded into little space, so that the reader feels that he needs much more to satisfy. A final short chapter on the care and feeding of snakes is included. Good photographs are abundant and a short list of selected books is added.

G. W. W.

BITS THAT GROW BIG, by Irma E. Webber. Board. 64 pages. 16×19.5 cm. 1949. William R. Scott, Inc., 513 Avenue of the Americas, New York 11, N. Y. Price $1.50.

Here is an excellent little book for children. It does not aim to tell all the story of plant reproduction but gives typical illustrations that can be set up in the class room or at home. The experiments are described in a few short clear sentences. Three or four important questions are asked to insure proper thought, but the pupil is not left without answers. To ask definite questions first then later to give correct and clearly worded answers is an excellent teaching plan. The illustrations are artistically done, simple and in color, on nearly every page, thus making an attractive book for the youngsters. You will want it for your elementary pupils.

G. W. W.

BASIC ELECTRICAL PRINCIPLES, by Maurice Grayle Suffern, B.S., LL.B., LL.M., *Major Ordnance Department, Army of the United States.* Cloth. Pages ix+430. 13.5×20.5 cm. 1949. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $3.20.

This book is designed for training students in the elements of electricity on a vocational education level. Only the simplest sort of mathematics is required yet, when the student gets through the course, he has learned to handle all the equations of arithmetic and algebra required. This is done by use of a great number of excellent diagrams and pictures, 275 in all, but many of these are in three or four parts so that the actual number of separate diagrams is much greater. The author starts in the first chapter by showing the electric current as a flow of electrons and continues in this manner throughout the text. As is usually the case on books for vocational students the author defines the ohm first, then the volt, and finally the ampere. In four chapters he has covered the principles of direct current work and has shown many of the practical applications. The next four chapters cover the principles and practice of alternating currents, giving

the students excellent explanations of inductance and capacitance and their effects in electric circuits. Chapters on the generator, the motor, rectification of alternating current, and the electric meter complete the study. The book is thorough and the material is well presented to the class of students for which it was written.

G. W. W.

AN INTRODUCTION TO MATHEMATICS, by A. N. Whitehead, *Waynflete Professor of Pure Mathematics in the University of Oxford.* Cloth. Pages v+191. 10.5 ×16.5 cm. 1948. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $2.00.

This is the first American edition of this book. Originally published in 1911, this is also the twelfth impression. It seeks to explain what mathematics is and how it forms the background of all science. Emphasis is placed upon fundamental ideas and theories.

The seventeen chapters of which the book is composed are intended not only to give one an idea about the general nature of mathematics but also to explain how important it is that one should understand it. No attempt is made to teach mathematics but the importance of its truths as a background for science is emphasized.

Although the author does not assume that one has studied mathematics through the Differential Calculus, the examples which he uses being explained as thoroughly and as simply as possible, it seems that one who has been a student of these courses would be better able to understand and appreciate the philosophy of mathematics which he develops. The theory underlying various courses becomes a part of this philosophy.

One statement in the book bears repeating. "It is a profoundly erroneous truism, repeated by all copy-books and by eminent people when they are making speeches, that we should cultivate the habit of thinking of what we are doing. The precise opposite is the case. Civilization advances by extending the number of important operations which we can perform without thinking about them. Operations of thought are like cavalry charges in a battle—they are strictly limited in number, they require fresh horses, and must only be made at decisive moments."

You should enjoy "An Introduction to Mathematics" and perhaps gain something from it which will continue to make your work in this subject more interesting.

ALBERT R. MAHIN
Broad Ripple High School
Indianapolis, Ind.

NEW SYLLABUS ALGEBRA, by C. O. Tuckey, *formerly Head Mathematical Master at Charterhouse,* and W. Armistead, *Head of the Mathematical School of Christ's Hospital.* With Answers. Cloth. Pages vii+201. 12.5×19 cm. 1948. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y.

The authors say "This book is intended for the use of those pupils whose Syllabus has been adjusted to conform to the modern view of the meaning of Elementary Mathematics." It is divided into three sections: The Beginnings, Proportion and Linear Functions, and Squares, Areas, Quadratics. The topics included in these sections are those which are generally found in algebra books, although the arrangement is a little different than in some books. The authors begin with number puzzles, then equations and problems.

The emphasis in this book is upon the concept of functionality, and an attempt is made to show its connection with Arithmetic and also its relation to geometry. The explanations of new processes as they are introduced seems adequate, but the number of exercises of any one type is small and if one wanted to use "New Syllabus" as a textbook it would be necessary to use supplementary material.

At the close of the book the authors have included some topics of algebraic interest. Included among these are the equation for the circle, progressions, Chinese rule for square root, Hero's formula, and uses of factorial n. The last chapter also includes six test papers as well as a set of Specimen Papers. The latter show the whole range of algebraic knowledge expected. Since the authors of this syllabus are English it is very interesting to compare their work with the algebra requirements of our textbooks, and although the arrangement is different, the topics included vary little, if any, from our requirements.

ALBERT R. MAHIN

YOUR MATHEMATICS, by George E. Hawkins, and Gladys Tate. Cloth. 592 pages. 14.5×22.5 cm. 1948. Scott, Foresman and Company, 433 East Erie Street, Chicago, Ill.

This is a general mathematics textbook. A series of Inventory Tests introduces the first topic, Review of Arithmetic, and these may be followed where necessary by remedial drill consisting of self-help tests and practice exercises which are placed in the back of the book. Illustrations and indicated conversations about new types of problems not only help to introduce new kinds of problems but also give the student some knowledge about desirable methods of approach and alternate methods of solution for them. Emphasis is placed upon creating ability to solve problems, and the numbers are so chosen that the method of solution rather than the use of numbers is most important.

Several other aspects of the book should be mentioned. Self-Testing Drills spaced throughout the book give the student a chance to determine how well he has mastered the preceding work and practice exercises to maintain the skills which he has learned. "Without pencil" exercises place emphasis upon ability to do mental calculation and side-trips in mathematics introduce useful ideas.

Topics in the book besides the Review of Arithmetic which has already been mentioned are Percentage, Formulas, Signed Numbers and Equations, Direct Measurement, Indirect Measurement, The Mathematics of Business, The Mathematics of Finance and Review of the Year's Work. The authors say that these deal "with the kind of mathematics that everyone needs to understand." Teachers interested in examining textbooks in general mathematics should include "Your Mathematics."

ALBERT R. MAHIN

INTERPRETING SCIENCE SERIES, 1947 Edition, by Franklin B. Carroll, *Head, Science Department, Frankford High School, Philadelphia, Pa.* Understanding Our Environment, Book I, 324 pages, 14.5×23 cm. Price $2.00. Understanding Our World, Book II, 426 pages. 14.5×23 cm. Price $2.24. Understanding the Universe, Book III, 568 pages. 14.5×23 cm. Price $2.48. The John C. Winston Company, Philadelphia, Pa.

The first impression one receives from the Winston series of general science texts for the seventh, eighth, and ninth grades is favorable and this impression is strengthened by closer scrutiny. The three volumes are well illustrated with diagrams, photographs in black and white, and photographs in color. The books are carefully written to motivate boys and girls on the junior high level. An illustration of this is the following question on page 20, Book One: Have you ever seen a "magician" give a performance? Can you explain any of his magic? The group of questions at this point are planned to develop notions of natural cause and effect as contrasted with superstition.

The treatment of facts and ideas is not superficial and the three books maintain a very acceptable standard. The books are organized to follow a very important pedagogical principle, namely, new concepts are developed *by the student* as he reacts to an experience. To achieve this, the books contain a large amount of pupil activity, both physical as well as mental. In this way students are taught to observe carefully and to generalize cautiously.

The books are largely successful in breaking down sharp subject matter lines

and in organizing the scientific content around larger units having the character of a problem. There is of necessity an overlap of topics from book to book, but the treatment is such as to cultivate from book to book increasing insight through new activities and new points of view. The words "environment," "world," and "universe" in the titles of the three books are not reliable indicators of content, although the last book has an extensive chapter on astronomy.

The books were written recently enough to have a fairly adequate treatment of such technical developments as atomic fission, radioactivity, radar, and the electron microscope. These discussions occur in the last book. Each of the volumes has a good index for reference purposes. Having taught science from grades four to twelve, the reviewer believes that these volumes would provide an important and satisfactory link in the science program.

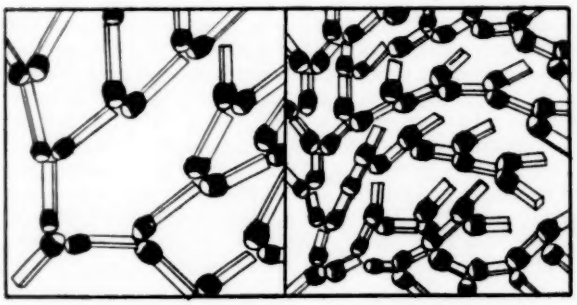
SHELDON S. MYERS
University School
Ohio State University

A DEMONSTRATION CHAIN REACTION

JAMES B. DAVIS
Lower Merion Senior High School, Ardmore, Penn.

A considerable amount of expensive equipment, such as the telephone, may be used by anyone for just one nickel. One of the basic principles of the atomic bomb, another billion dollar enterprise, may be demonstrated by the outlay of a like sum.

The accompanying drawing illustrates how ordinary wooden matches may be arranged to show the idea of a chain reaction. The diagram on the right shows a fast reaction. (The matches are only $\frac{3}{8}$ of an inch long). The diagram on the left shows the effect of a moderator by using matches $\frac{5}{8}$ of an inch long. Both reactions start by lighting the match at the lower left hand corner.



Blotter-like strips, filled with tiny dry crystals of three powerful insecticides, are designed to use on house floors where insects crawl, or in pantries, clothes closets and under mattresses. Crawling vermin, from cockroaches to fleas, are killed by them.

SHOULD "A NATIONAL SCIENCE DAY" OR "A NATIONAL SCIENCE WEEK" BE ORGANIZED AND OBSERVED BY SCIENTISTS IN THE UNITED STATES?

The National Science Teachers Association is studying the advisability of putting the following proposal into effect: "Shall N.S.T.A. take the lead in proposing and sponsoring a science public relations program to be observed during 'A National Science Day' or 'A National Science Week' in the United States?"

This program was presented to the Association with the view to accomplishing the following major objectives:

1. To promote science and the science professions on a national basis.
2. To enable the scientists to become better acquainted with each other and one another's work.
3. To honor the workers in the various fields of science.
4. To acquaint laymen with the contributions of pure and applied science. Too frequently they learn of science only in connection with atomic bombs and other destructive agents. They should know also that scientific minds and laboratories are constantly at work devising and producing for their comfort and health such items as pop-up toasters, thermostats, deep-freeze units, television, and penicillin. The better acquainted laymen become with science, the more value it has to them, and the less biased they are toward it and society.

These questions may be asked. 1. To whom should responsibility be delegated for this program? What promotional aids would be available to teachers? Obviously, the program's success would depend upon inclusion and cooperation of all science organizations. Ultimately, the success of this project would rest upon the individual science teachers throughout the nation. Pamphlets describing programs suitable for class room use, science assemblies, night science meetings, service clubs, women's clubs, etc., could be made available. Other avenues for observing such an occasion would include science articles in local newspapers by teachers and other technically trained men and women in the community, radio networks, and news releases.

We, who work in science, are aware that the record of scientific achievement is a commendable one. Few professions offer a comparable galaxy of notable men and women, both past and present, who have and are contributing to man's well being. Why, then, do not we science teachers pay honor to our profession and its workers and, at the same time, direct our efforts toward increasing an understanding of the practicability of scientific methods and products to laymen.

A committee has been appointed by N.S.T.A. to determine the feasibility of this program, and to submit a report at the Boston meeting in July, 1949.

To bring this matter to the science teachers over the Nation, editors of science journals have been invited to assist the committee by giving magazine space to this brief article and questionnaire. Specifically, the committee wishes to learn the attitude of scientists, from both the fields of industry and teaching, in the United States regarding this project. THEREFORE, EVERY READER OF THIS JOURNAL IS URGED TO CONTACT A MEMBER OF THE COMMITTEE AND EXPRESS HIS OR HER OPINION REGARDING THE DESIRABILITY OF ONE OF THE FOLLOWING: 1. A National Science Day. 2. A National Science Week. 3. Would you assist by supporting and promoting such a program in your local school system and community? The committee members are as follows:

1. Dr. Earl R. Glenn
   State Teachers College
   Upper Montclair, New Jersey
2. Dr. Walter S. Lapp
   724 Derstine Avenue
   Lansdale, Pa.
3. Mr. Lee R. Yothers, Chairman
   Rahway High School
   Rahway, New Jersey